
# Recommendations for Use of Antiretroviral Drugs in Pregnant HIV-1-Infected Women for Maternal Health and Interventions to Reduce Perinatal HIV Transmission in the United States



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# Recommendations for Use of Antiretroviral Drugs in Pregnant HIV-1-Infected Women for Maternal Health *and* Interventions to Reduce Perinatal HIV Transmission in the United States


Developed by the HHS Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission — A Working Group of the Office of AIDS Research Advisory Council (OARAC)

**How to Cite the Perinatal Guidelines:**

Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission. Recommendations for Use of Antiretroviral Drugs in Pregnant HIV-1-Infected Women for Maternal Health *and* Interventions to Reduce Perinatal HIV Transmission in the United States. Available at http://aidsinfo.nih.gov/contentfiles/lvguidelines/PerinatalGL.pdf. Accessed (insert date) [include page numbers, table number, etc. if applicable]

It is emphasized that concepts relevant to HIV management evolve rapidly. The Panel has a mechanism to update recommendations on a regular basis, and the most recent information is available on the AIDS*info* website (http://aidsinfo.nih.gov).

access AIDS*info* mobile site

## What's New in the Guidelines? (Last updated July 31, 2012; last reviewed July 31, 2012)

Key changes made to update the September 14, 2011, version of the guidelines are summarized below. Throughout the revised guidelines, significant updates are highlighted and discussed. The addendum to the guidelines—**Supplement: Safety and Toxicity of Individual Antiretroviral Agents in Pregnancy**—includes updated information from the Antiretroviral Pregnancy Registry and updates on recent studies of various antiretroviral agents in human pregnancy.

### Lessons from Clinical Trials of Antiretroviral Interventions to Reduce Perinatal Transmission of HIV and Table 3, Results of Major Studies on Antiretroviral Prophylaxis to Prevent Mother-to-Child Transmission of HIV:

- Table 3 updated to include data on 48-week results of the Breastfeeding and Nutrition (BAN) study in Malawi.

### Preconception Counseling and Care for HIV-Infected Women of Childbearing Age and Table 4, Drug Interactions Between Hormonal Contraceptives and Antiretroviral Agents:

- Table 4 updated to include data on hormonal contraceptive interactions with rilpivirine and raltegravir.
- **Reproductive Options for HIV-Concordant and Serodiscordant Couples:**
  - For serodiscordant couples who want to conceive, use of antiretroviral therapy is now recommended for the HIV-infected partner, with the strength of the recommendation differing based on the CD4-cell count of the infected partner:
    - **AI** for CD4 T-lymphocyte (CD4-cell) count ≤550 cells/mm$^3$, **BIII** for CD4-cell count >550 cells/mm$^3$). If therapy is initiated, maximal viral suppression is recommended before conception is attempted **(AIII)**.
  - Added discussion of the pre-exposure prophylaxis (PrEP) studies in heterosexual couples, with a new recommendation regarding PrEP in discordant couples who wish to conceive. Discussion includes information on counseling, laboratory testing, and monitoring of individuals on PrEP and importance of reporting uninfected women who become pregnant on PrEP to the Antiretroviral Pregnancy Registry:
    - Periconception administration of antiretroviral PrEP for HIV-uninfected partners may offer an additional tool to reduce the risk of sexual transmission **(CIII)**. The utility of PrEP of the uninfected partner when the infected partner is receiving antiretroviral therapy has not been studied.

### Antepartum Care

- **General Principles Regarding Use of Antiretroviral Drugs During Pregnancy:**
  - Initial assessment for HIV-infected pregnant women expanded to include screening for hepatitis C virus and tuberculosis infection, as well as history of side effects or toxicities from prior antiretroviral drug regimens.
  - Additional benefit of antiretroviral drug regimens expanded to include benefits of therapy for reducing sexual transmission to discordant partners when viral suppression is maintained, with

discussion of the HPTN 052 trial results.

- **Recommendations for Use of Antiretroviral Drugs During Pregnancy and Table 5, Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy:**

  - Modified recommendations regarding categorization of various antiretroviral agents in categories of drugs that are ***preferred***, ***alternative***, or ***use in special circumstances***.

  - **Nucleoside reverse transcriptase inhibitors:**
    - Didanosine and stavudine moved from ***alternative*** NRTI category to ***use in special circumstances*** category because they have more toxicity than the preferred and alternative NRTI drugs.

  - **Protease inhibitors:**
    - Atazanavir with low-dose ritonavir boosting moved from an ***alternative*** protease inhibitor to a ***preferred*** protease inhibitor for use in antiretroviral-naive pregnant women, along with lopinavir/ritonavir, because of increased information on safety in pregnancy.

    - Darunavir moved from ***insufficient data to recommend use*** to an ***alternative*** protease inhibitor for use in antiretroviral-naive pregnant women.

  - **Integrase inhibitors:**
    - Raltegravir moved from ***insufficient data to recommend use*** to ***use in special circumstances*** for antiretroviral-naive pregnant women when preferred or alternative agents cannot be used.

- **HIV-Infected Pregnant Women Who Have Never Received Antiretroviral Drugs (Antiretroviral Naive):**

  - Increased discussion on when to initiate an antiretroviral drug regimen in pregnant women:
    - The decision as to whether to start the regimen in the first trimester or delay until 12 weeks' gestation will depend on CD4-cell count, HIV RNA levels, and maternal conditions such as nausea and vomiting **(AIII)**. Earlier initiation of a combination antiretroviral regimen may be more effective in reducing transmission, but benefits must be weighed against potential fetal effects of first-trimester drug exposure.

- **HIV-Infected Pregnant Women Who Are Currently Receiving Antiretroviral Therapy:**

  - Discussion of efavirenz use in the first trimester:
    - Because the risk of neural tube defects is restricted to the first 5 to 6 weeks of pregnancy and pregnancy is rarely recognized before 4 to 6 weeks of pregnancy, and unnecessary antiretroviral drug changes during pregnancy may be associated with loss of viral control and increased risk of perinatal transmission, efavirenz can be continued in pregnant women receiving an efavirenz-based regimen who present for antenatal care in the first trimester, provided the regimen produces virologic suppression **(CIII)**.

- **Special Situations - Failure of Viral Suppression:**

  - Use of raltegravir in late pregnancy in women with high viral loads to decrease viral load discussed but not endorsed. The efficacy and safety of this approach have not been evaluated and

only anecdotal reports are available. In the setting of a failing regimen related to nonadherence and/or resistance, there are concerns that the addition of a single agent may further increase risk of resistance and potential loss of future effectiveness with raltegravir. Until more data become available on the safety of raltegravir use in pregnancy, this approach cannot be recommended.

## Special Considerations Regarding the Use of Antiretroviral Drugs by HIV-Infected Pregnant Women and Their Infants

- **Combination Antiretroviral Drug Regimens and Pregnancy Outcome:**
  - Addition of a new table—Table 7– Results of Studies Assessing Association Between Antiretroviral Regimens and Preterm Delivery—that summarizes the results of studies assessing the association between antiretroviral regimens and preterm delivery.

## Intrapartum Care

- **Intrapartum Antiretroviral Therapy/Prophylaxis:**
  - Discussion of use of intravenous (IV) zidovudine during labor and maternal viral load:
    - IV zidovudine is no longer required for HIV-infected women receiving combination antiretroviral regimens who have HIV RNA <400 copies/mL near delivery **(BII)**.
    - HIV-infected women with HIV RNA ≥400 copies/mL (or unknown HIV RNA) near delivery should be administered IV zidovudine during labor, regardless of antepartum regimen or mode of delivery **(AI)**.
    - Based on pharmacokinetic data, in women with HIV RNA ≥400 copies/mL near delivery for whom zidovudine is recommended, IV would be preferred to oral administration in the United States; in situations where IV administration is not possible, oral administration can be considered.

## Postpartum Care

- **Infant Antiretroviral Prophylaxis and Table 9, Recommended Neonatal Dosing for Prevention of Mother-to-Child Transmission of HIV:**
  - Table 9 revised to reflect neonatal dosing only of zidovudine (in term and preterm infants) and nevirapine in the regimen used in the NICHD-HPTN 040 study.
  - Choice of neonatal antiretroviral drug prophylaxis includes discussion of the NICHD-HPTN 040 study and concerns regarding use of lopinavir/ritonavir in neonates.
  - Addition of new pharmacokinetic data on nevirapine in preterm infants.
- **Initial Postnatal Management of the HIV-Exposed Neonate:**
  - Because of the potential for enhanced hematologic toxicity in infants receiving a zidovudine/lamivudine-containing prophylaxis regimen, a recheck of hemoglobin and neutrophil counts is recommended 4 weeks after initiation of prophylaxis **(AI)**.
  - New recommendation that health care providers should routinely inquire about premastication of foods fed to infants, instruct HIV-infected caregivers to avoid this practice, and advise on safer feeding options **(AII)**.

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## *Tables*

# Members of the Panel on Treatment of HIV-Infected Pregnant Woman and Prevention of Perinatal Transmission (Last updated July 31, 2012; last reviewed July 31, 2012)

Revisions to the September 14, 2011, Recommendations for Use of Antiretroviral Drugs in Pregnant HIV-1-Infected Women for Maternal Health *and* Interventions to Reduce Perinatal Transmission in the United States have been made by the Department of Health and Human Services (HHS) Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission (a Working Group of the Office of AIDS Research Advisory Council).

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** Dr. Handelsman died suddenly on March 4, 2012. He is remembered as a leader in and advocate of pediatric and perinatal HIV research. Panel members hope to honor Dr. Handelsman's legacy by continuing his work to save the lives of women and children worldwide.*

# Financial Disclosure List for Members of the HHS Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission (Last updated July 31, 2012; last reviewed July 31, 2012)

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DSMB = Data Safety Monitoring Board, ES = Executive Secretary, ExOM = Ex Officio Member, HHS = Member from HHS, M = Member, N/A = Not applicable, NVO = Nonvoting Observer

## Introduction (Last updated July 31, 2012; last reviewed July 31, 2012)

Recommendations regarding HIV screening and treatment of pregnant women and prophylaxis for perinatal transmission of HIV have evolved considerably in the United States over the last 25 years, reflecting changes in the epidemic and the science of prevention.[1, 2] With the implementation of recommendations for universal prenatal HIV counseling and testing, antiretroviral (ARV) prophylaxis, scheduled cesarean delivery, and avoidance of breastfeeding, the rate of perinatal transmission of HIV has dramatically diminished to less than 2% in the United States and Europe.[3-6]

These guidelines update the September 14, 2011, Recommendations for Use of Antiretroviral Drugs in Pregnant HIV-1-Infected Women for Maternal Health *and* Interventions to Reduce Perinatal HIV Transmission in the United States. The Department of Health and Human Services Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission, a working group of the Office of AIDS Research Advisory Council, develops these guidelines. The guidelines provide health care providers with information for discussion with HIV-infected pregnant women to enable the patient/provider team to make informed decisions regarding the use of ARV drugs during pregnancy and use of scheduled cesarean delivery to reduce perinatal transmission of HIV. The recommendations in the guidelines are accompanied by discussion of various circumstances that commonly occur in clinical practice and the factors influencing treatment considerations. The Panel recognizes that strategies to prevent perinatal transmission and concepts related to management of HIV disease in pregnant women are rapidly evolving and will consider new evidence and adjust recommendations accordingly. The updated guidelines are available from the AIDS*info* website (http://aidsinfo.nih.gov).

Health care providers considering the use of ARV agents for HIV-infected women during pregnancy must take into account two separate but related issues:

1. ARV treatment of maternal HIV infection and
2. ARV chemoprophylaxis to reduce the risk of perinatal transmission of HIV.

The benefits of ARV drugs for a pregnant woman must be weighed against the risks of adverse events to the woman, fetus, and newborn. Combination drug regimens are considered the standard of care both for treatment of HIV infection and for prevention of perinatal transmission of HIV.[2, 7] After provider counseling and discussion on ARV drug use during pregnancy, a pregnant woman's informed choice on whether to take ARV drugs for her treatment, for prevention of mother-to-child transmission, and/or to follow other medical recommendations intended to reduce perinatal transmission of HIV should be respected. Coercive and punitive policies are potentially counterproductive; they may undermine provider-patient trust and could discourage women from seeking prenatal care and adopting health care behaviors that optimize fetal and neonatal well-being.

The current guidelines have been structured to reflect the management of an individual mother-child pair and are organized into a brief discussion of preconception care followed by principles for management of a woman and her infant during the antepartum, intrapartum, and postpartum periods. Although perinatal transmission of HIV occurs worldwide, these recommendations have been developed for use in the United States. Alternative strategies may be appropriate in other countries. Policies and practices in other countries regarding the use of ARV drugs for reduction of perinatal transmission of HIV may differ from the recommendations in these guidelines and will depend on local considerations, including availability and cost of ARV drugs, accessibility of facilities for safe intravenous infusions during labor, and local recommendations regarding breastfeeding by HIV-infected women.

## Guidelines Development Process

**Table 1. Outline of the Guidelines Development Process**

| Topic | Comment |
|---|---|
| **Goal of the guidelines** | Provide guidance to HIV care practitioners on the optimal use of antiretroviral (ARV) agents in pregnant women for treatment of HIV infection and for prevention of mother-to-child transmission (PMTCT) of HIV in the United States. |
| **Panel members** | The Panel is composed of approximately 30 voting members who have expertise in management of pregnant HIV-infected women (such as training in either obstetrics/gynecology or women's health) and interventions for PMTCT (such as specialized training in pediatric HIV infection) as well as community representatives with knowledge of HIV infection in pregnant women and interventions for PMTCT. The U.S. government representatives, appointed by their agencies, include at least 1 representative from each of the following Department of Health and Human Services agencies: the Centers for Disease Control and Prevention, the Food and Drug Administration (FDA), the Health Resources and Services Administration (HRSA), and the National Institutes of Health (NIH). Members who do not represent U.S. government agencies are selected by Panel members after an open announcement to call for nominations. Each member serves on the Panel for a 3-year period, with an option for reappointment. A list of all Panel members can be found in the Panel Roster. |
| **Financial disclosures** | All members of the Panel submit a written financial disclosure annually reporting any association with manufacturers of ARV drugs or diagnostics used for management of HIV infections. A list of the latest disclosures is available on the AIDS*info* website (http://aidsinfo.nih.gov). |
| **Users of the guidelines** | Providers of care to HIV-infected pregnant women and to HIV-exposed infants |
| **Developer** | Panel on Treatment of HIV-Infected Pregnant Women and Prevention of Perinatal Transmission—a working group of OARAC |
| **Funding source** | Office of AIDS Research, NIH |
| **Evidence for recommendations** | The recommendations in these guidelines are generally based on studies published in peer-reviewed journals. On some occasions, particularly when new information may affect patient safety, unpublished data presented at major conferences or prepared by the FDA and/or manufacturers as warnings to the public may be used as evidence to revise the guidelines. |
| **Recommendation grading** | See Table 2. |
| **Method of synthesizing data** | Each section of the guidelines is assigned to a small group of Panel members with expertise in the area of interest. A structured literature search is conducted by staff from the HIV/AIDS National Resource Center at the Francois-Xavier Bagnoud Center (through funding from HRSA) and provided to the Panel working group. The members review and synthesize the available data and propose recommendations to the entire Panel. The Panel discusses and votes on all proposals during monthly teleconferences. Proposals receiving endorsement from a consensus of members are included in the guidelines as official Panel recommendations. |
| **Other guidelines** | These guidelines focus on HIV-infected pregnant women and their infants. Other guidelines outline the use of ARV agents in non-pregnant HIV-infected adults and adolescents, HIV-infected children, and people who experience occupational or nonoccupational exposure to HIV. The guidelines described are also available on the AIDS*info* website (http://aidsinfo.nih.gov). Preconception management for non-pregnant women of reproductive age is briefly discussed in this document. However, for more detailed discussion on issues of treatment of non-pregnant adults, the Working Group defers to the designated expertise offered by Panels that have developed those guidelines. |

## Guidelines Development Process

**Table 1. Outline of the Guidelines Development Process, cont'd**

| Topic | Comment |
|---|---|
| **Update plan** | The Panel meets monthly by teleconference to review data that may warrant modification of the guidelines. Updates may be prompted by new drug approvals (or new indications, new dosing formulations, or changes in dosing frequency), significant new safety or efficacy data, or other information that may have a significant impact on the clinical care of patients. In the event of significant new data that may affect patient safety, the Panel may issue a warning announcement and accompanying recommendations on the AIDS*info* website until the guidelines can be updated with appropriate changes. Updated guidelines are available at the AIDS*info* website (http://aidsinfo.nih.gov). |
| **Public comments** | A 2-week public comment period follows release of the updated guidelines on the AIDS*info* website. The Panel reviews comments received to determine whether additional revisions to the guidelines are indicated. The public may also submit comments to the Panel at any time at contactus@aidsinfo.nih.gov. |

### *Basis for Recommendations*

Recommendations in these guidelines are based on scientific evidence and expert opinion. Each recommended statement is rated with a letter of **A**, **B**, or **C** that represents the strength of the recommendation and with a numeral **I**, **II**, or **III**, according to the quality of evidence.

**Table 2. Rating Scheme for Recommendations**

| Strength of Recommendation | Quality of Evidence for Recommendation |
|---|---|
| **A:** Strong recommendation for the statement<br>**B:** Moderate recommendation for the statement<br>**C:** Optional recommendation for the statement | **I:** One or more randomized trials with clinical outcomes and/or validated laboratory endpoints<br>**II:** One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes<br>**III:** Expert opinion |

## References


1. Centers for Disease Control and Prevention. Achievements in public health. Reduction in perinatal transmission of HIV infection—United States, 1985-2005. *MMWR Morb Mortal Wkly Rep*. Jun 2 2006;55(21):592-597. Available at http://www.ncbi.nlm.nih.gov/pubmed/16741495.
2. Jamieson DJ, Clark J, Kourtis AP, et al. Recommendations for human immunodeficiency virus screening, prophylaxis, and treatment for pregnant women in the United States. *Am J Obstet Gynecol*. Sep 2007;197(3 Suppl):S26-32. Available at http://www.ncbi.nlm.nih.gov/pubmed/17825647.
3. Birkhead GS, Pulver WP, Warren BL, Hackel S, Rodriguez D, Smith L. Acquiring human immunodeficiency virus during pregnancy and mother-to-child transmission in New York: 2002-2006. *Obstet Gynecol*. Jun 2010;115(6):1247-1255. Available at http://www.ncbi.nlm.nih.gov/pubmed/20502297.
4. Cooper ER, Charurat M, Mofenson L, et al. Combination antiretroviral strategies for the treatment of pregnant HIV-1-infected women and prevention of perinatal HIV-1 transmission. *J Acquir Immune Defic Syndr*. Apr 15 2002;29(5):484-494. Available at http://www.ncbi.nlm.nih.gov/pubmed/11981365.

5. Townsend CL, Cortina-Borja M, Peckham CS, de Ruiter A, Lyall H, Tookey PA. Low rates of mother-to-child transmission of HIV following effective pregnancy interventions in the United Kingdom and Ireland, 2000-2006. *AIDS*. May 11 2008;22(8):973-981. Available at http://www.ncbi.nlm.nih.gov/pubmed/18453857.

6. Birkhead GS, Pulver WP, Warren BL, et al. Progress in prevention of mother-to-child transmission of HIV in New York State: 1988-2008. *J Public Health Manag Pract*. Nov-Dec 2010;16(6):481-491. Available at http://www.ncbi.nlm.nih.gov/pubmed/20885177.

7. Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents. Department of Health and Human Services. Available at http://aidsinfo.nih.gov/contentfiles/lvguidelines/AdultandAdolescentGL.pdf. Accessed June 15, 2012.

# Lessons from Clinical Trials of Antiretroviral Interventions to Reduce Perinatal Transmission of HIV (Last updated July 31, 2012; last reviewed July 31, 2012)

## Overview

One of the major achievements in HIV research was the demonstration by the Pediatric AIDS Clinical Trials Group 076 (PACTG 076) clinical trial that administration of zidovudine to pregnant women and their infants could reduce risk of perinatal transmission by nearly 70%.[1] Following the results of PACTG 076, in the United States and in other resource-abundant countries, implementation of the zidovudine regimen coupled with increased antenatal HIV counseling and testing rapidly resulted in significant declines in transmission.[2-5] Subsequent clinical trials and observational studies demonstrated that combination antiretroviral (ARV) prophylaxis (initially dual- and then triple-combination therapy) given to a mother antenatally was associated with further declines in transmission to less than 2%.[2, 6, 7] Current estimates indicate that fewer than 200 HIV-infected infants are now born each year in the United States.[4, 8, 9]

Each individual birth of an infected infant is a sentinel event representing missed opportunities and barriers to prevention.[10, 11] Important obstacles to elimination of perinatal transmission in the United States include the continued increase in HIV infection in women of childbearing age;[12] absent or delayed prenatal care, particularly in women using illicit drugs; acute (primary) infection in late pregnancy and in women who are breastfeeding; poor adherence to prescribed ARV regimens in pregnant women; and lack of full implementation of routine, universal prenatal HIV counseling and testing.[9, 11, 13]

Following the results of PACTG 076, researchers began to explore the development of shorter, less expensive prophylactic regimens more applicable to resource-constrained settings. Clinical trials initially focused on shortened zidovudine-alone prophylaxis regimens and moved to evaluating whether combination ARV regimens, such as short-course zidovudine combined with lamivudine, might have improved efficacy over zidovudine alone. Studies also evaluated whether even simpler, less expensive, single-drug regimens, such as single-dose intrapartum/neonatal nevirapine, would be effective and whether combining such regimens with other short-course regimens might result in improved efficacy. These studies have provided important insights into the mechanisms of action of ARV drugs in reducing perinatal transmission and in determining optimal regimens for use in the United States and other resource-rich countries.

## References


1. Connor EM, Sperling RS, Gelber R, et al. Reduction of maternal-infant transmission of human immunodeficiency virus type 1 with zidovudine treatment. Pediatric AIDS Clinical Trials Group Protocol 076 Study Group. *N Engl J Med*. Nov 3 1994;331(18):1173-1180. Available at http://www.ncbi.nlm.nih.gov/pubmed/7935654.
2. Cooper ER, Charurat M, Mofenson L, et al. Combination antiretroviral strategies for the treatment of pregnant HIV-1-infected women and prevention of perinatal HIV-1 transmission. *J Acquir Immune Defic Syndr*. Apr 15 2002;29(5):484-494. Available at http://www.ncbi.nlm.nih.gov/pubmed/11981365.
3. Wortley PM, Lindegren ML, Fleming PL. Successful implementation of perinatal HIV prevention guidelines. A multistate surveillance evaluation. *MMWR Recomm Rep*. May 11 2001;50(RR-6):17-28. Available at http://www.ncbi.nlm.nih.gov/pubmed/15580801.
4. Centers for Disease Control and Prevention. Achievements in public health. Reduction in perinatal transmission of HIV infection--United States, 1985-2005. *MMWR Morb Mortal Wkly Rep*. Jun 2 2006;55(21):592-597. Available at http://www.ncbi.nlm.nih.gov/pubmed/16741495.

5. European Collaborative Study. HIV-infected pregnant women and vertical transmission in Europe since 1986. European collaborative study. *AIDS*. 2001;15(6):761-770. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=11371691.

6. Mandelbrot L, Landreau-Mascaro A, Rekacewicz C, et al. Lamivudine-zidovudine combination for prevention of maternal-infant transmission of HIV-1. *JAMA*. Apr 25 2001;285(16):2083-2093. Available at http://www.ncbi.nlm.nih.gov/pubmed/11311097.

7. Dorenbaum A, Cunningham CK, Gelber RD, et al. Two-dose intrapartum/newborn nevirapine and standard antiretroviral therapy to reduce perinatal HIV transmission: a randomized trial. *JAMA*. Jul 10 2002;288(2):189-198. Available at http://www.ncbi.nlm.nih.gov/pubmed/12095383.

8. McKenna MT, Hu X. Recent trends in the incidence and morbidity that are associated with perinatal human immunodeficiency virus infection in the United States. *Am J Obstet Gynecol*. Sep 2007;197(3 Suppl):S10-16. Available at http://www.ncbi.nlm.nih.gov/pubmed/17825639.

9. Rogers MF, Taylor AW, Nesheim SR. Preventing perinatal transmission of HIV: the national perspective. *J Public Health Manag Pract*. Nov-Dec 2010;16(6):505-508. Available at http://www.ncbi.nlm.nih.gov/pubmed/20885179.

10. Peters V, Liu KL, Gill B, et al. Missed opportunities for perinatal HIV prevention among HIV-exposed infants born 1996-2000, pediatric spectrum of HIV disease cohort. *Pediatrics*. Sep 2004;114(3):905-906. Available at http://www.ncbi.nlm.nih.gov/pubmed/15342884.

11. Whitmore SK, Taylor AW, Espinoza L, Shouse RL, Lampe MA, Nesheim S. Correlates of mother-to-child transmission of HIV in the United States and Puerto Rico. *Pediatrics*. Jan 2012;129(1):e74-81. Available at http://www.ncbi.nlm.nih.gov/pubmed/22144694.

12. Whitmore SK, Zhang X, Taylor AW, Blair JM. Estimated number of infants born to HIV-infected women in the United States and five dependent areas, 2006. *J Acquir Immune Defic Syndr*. Jul 1 2011;57(3):218-222. Available at http://www.ncbi.nlm.nih.gov/pubmed/21372725.

13. Whitmore SK, Patel-Larson A, Espinoza L, Ruffo NM, Rao S. Missed opportunities to prevent perinatal human immunodeficiency virus transmission in 15 jurisdictions in the United States during 2005-2008. *Women Health*. Jul 2010;50(5):414-425. Available at http://www.ncbi.nlm.nih.gov/pubmed/20853217.

## Mechanisms of Action of Antiretroviral Prophylaxis in Reducing Perinatal Transmission of HIV (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendation |
|---|
| • Antiretroviral (ARV) drugs reduce perinatal transmission by several mechanisms, including lowering maternal antepartum viral load and providing infant pre- and post-exposure prophylaxis. Therefore, combined antepartum, intrapartum, and infant ARV prophylaxis is recommended to prevent perinatal transmission of HIV **(AI)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

Antiretroviral (ARV) drugs can reduce perinatal transmission through a number of mechanisms. Antenatal drug administration decreases maternal viral load in blood and genital secretions, which is a particularly important mechanism of action in women with high viral loads. Even among women with HIV RNA levels <1,000 copies/mL, however, ARV drugs have been shown to reduce risk of transmission.[1] In addition, the level of HIV RNA at delivery and receipt of antenatal ARV drugs are independently associated with risk of transmission, suggesting that reduction in viral load is not solely responsible for the efficacy of ARV prophylaxis.[2, 3]

Another mechanism of protection is infant pre-exposure prophylaxis achieved by administering ARV drugs that cross the placenta from mothers to infants and produce adequate systemic drug levels in the infants. This mechanism of protection likely is particularly important during passage through the birth canal, a time when infants receive intensive exposure to maternal genital-tract virus. Infant post-exposure prophylaxis is achieved by administering drugs to infants after birth. This intervention provides protection from cell-free or cell-associated virus that may have entered the fetal/infant systemic circulation through maternal-fetal transfusion associated with uterine contractions during labor or systemic dissemination of virus swallowed during infant passage through the birth canal.

The efficacy of ARV drugs in reducing perinatal transmission likely is multifactorial, and each of the mechanisms previously described may make a contribution. The importance of the pre- and post-exposure components of prophylaxis in reducing perinatal transmission is demonstrated by the efficacy of interventions that involve administration of ARVs only during labor and/or to the newborns, discussed in the next section.[4-10]

## References


1. Ioannidis JP, Abrams EJ, Ammann A, et al. Perinatal transmission of human immunodeficiency virus type 1 by pregnant women with RNA virus loads <1000 copies/ml. *J Infect Dis*. Feb 15 2001;183(4):539-545. Available at http://www.ncbi.nlm.nih.gov/pubmed/11170978.
2. Cooper ER, Charurat M, Mofenson L, et al. Combination antiretroviral strategies for the treatment of pregnant HIV-1-infected women and prevention of perinatal HIV-1 transmission. *J Acquir Immune Defic Syndr*. Apr 15 2002;29(5):484-494. Available at http://www.ncbi.nlm.nih.gov/pubmed/11981365.
3. Sperling RS, Shapiro DE, Coombs RW, et al. Maternal viral load, zidovudine treatment, and the risk of transmission of human immunodeficiency virus type 1 from mother to infant. Pediatric AIDS Clinical Trials Group Protocol 076 Study Group. *N Engl J Med*. Nov 28 1996;335(22):1621-1629. Available at http://www.ncbi.nlm.nih.gov/pubmed/8965861.

4. Jackson JB, Musoke P, Fleming T, et al. Intrapartum and neonatal single-dose nevirapine compared with zidovudine for prevention of mother-to-child transmission of HIV-1 in Kampala, Uganda: 18-month follow-up of the HIVNET 012 randomised trial. *Lancet*. Sep 13 2003;362(9387):859-868. Available at http://www.ncbi.nlm.nih.gov/pubmed/13678973.

5. Petra Study Team. Efficacy of three short-course regimens of zidovudine and lamivudine in preventing early and late transmission of HIV-1 from mother to child in Tanzania, South Africa, and Uganda (Petra study): a randomised, double-blind, placebo-controlled trial. *Lancet*. Apr 6 2002;359(9313):1178-1186. Available at http://www.ncbi.nlm.nih.gov/pubmed/11955535.

6. Moodley D, Moodley J, Coovadia H, et al. A multicenter randomized controlled trial of nevirapine versus a combination of zidovudine and lamivudine to reduce intrapartum and early postpartum mother-to-child transmission of human immunodeficiency virus type 1. *J Infect Dis*. Mar 1 2003;187(5):725-735. Available at http://www.ncbi.nlm.nih.gov/pubmed/12599045.

7. Taha TE, Kumwenda NI, Gibbons A, et al. Short postexposure prophylaxis in newborn babies to reduce mother-to-child transmission of HIV-1: NVAZ randomised clinical trial. *Lancet*. Oct 11 2003;362(9391):1171-1177. Available at http://www.ncbi.nlm.nih.gov/pubmed/14568737.

8. Gaillard P, Fowler MG, Dabis F, et al. Use of antiretroviral drugs to prevent HIV-1 transmission through breast-feeding: from animal studies to randomized clinical trials. *J Acquir Immune Defic Syndr*. Feb 1 2004;35(2):178-187. Available at http://www.ncbi.nlm.nih.gov/pubmed/14722452.

9. Gray GE, Urban M, Chersich MF, et al. A randomized trial of two postexposure prophylaxis regimens to reduce mother-to-child HIV-1 transmission in infants of untreated mothers. *AIDS*. Aug 12 2005;19(12):1289-1297. Available at http://www.ncbi.nlm.nih.gov/pubmed/16052084.

10. Nielsen-Saines K, Watts DH, Veloso VG, et al. Three postpartum antiretroviral regimens to prevent intrapartum HIV infection. *N Engl J Med*. Jun 21 2012;366(25):2368-2379. Available at http://www.ncbi.nlm.nih.gov/pubmed/22716975.

## Lessons from International Clinical Trials of Short-Course Antiretroviral Regimens for Prevention of Perinatal Transmission of HIV (Last updated July 31, 2012; last reviewed July 31, 2012)

A number of regimens have been identified that are effective in reducing perinatal transmission in resource-limited countries (see Table 3). In many cases, direct comparison of results from trials of these regimens is not possible because the studies involved diverse patient populations residing in different geographic locations, infected with diverse viral subtypes, and with different infant feeding practices. However, some generalizations are relevant to understanding use of antiretroviral (ARV) drugs for prevention of perinatal transmission in both resource-limited and resource-rich countries.

*Combination antenatal prophylaxis taken over a longer duration is more effective than a short-course single-drug regimen in reducing perinatal transmission.*

The use of ARV drugs to prevent transmission is highly effective, even in HIV-infected women with advanced disease.[1, 2] Efficacy has been demonstrated for a number of short-course ARV regimens, including those with zidovudine alone; zidovudine plus lamivudine; single-dose nevirapine; and single-dose nevirapine combined with either short-course zidovudine or zidovudine/lamivudine.[3-12] In general, combination regimens are more effective than single-drug regimens in reducing perinatal transmission. In addition, for prevention of perinatal transmission, administration of ARV drugs during the antepartum, intrapartum, and postpartum periods is superior to administration of ARV drugs only during the antepartum and intrapartum periods or intrapartum and postpartum periods.[4, 13, 14]

Almost all trials in resource-limited countries have included oral intrapartum prophylaxis, with varying durations of maternal antenatal and/or infant (and sometimes maternal) postpartum prophylaxis. Perinatal transmission is reduced by regimens with antenatal components starting as late as 36 weeks' gestation and lacking an infant prophylaxis component.[9-11] However, longer duration antenatal ARV prophylaxis (starting at 28 weeks' gestation) is more effective than shorter duration ARV prophylaxis (starting at 36 weeks' gestation), suggesting that a significant proportion of *in utero* transmission occurs between 28 and 36 weeks' gestation.[12] Analyses from the European National Study of HIV in Pregnancy and Childhood have shown that efficacy is increased with even longer duration antenatal ARV prophylaxis (starting before 28 weeks' gestation), with each additional week of a triple-drug regimen corresponding to a 10% reduction in risk of transmission after adjustment for viral load, mode of delivery, and sex of the infant.[15] More prolonged infant post-exposure prophylaxis does not appear to substitute for longer duration maternal ARV prophylaxis.[12]

No trials have directly compared the efficacy of zidovudine plus single-dose nevirapine with a triple-drug ARV regimen for prevention of *in utero* transmission in women with higher CD4 T-lymphocyte (CD4-cell) counts. In African women with CD4-cell counts ranging from 200 to 500 cells/mm$^3$, the Kesho Bora trial compared a triple-ARV drug prophylaxis regimen with zidovudine plus single-dose nevirapine prophylaxis, both started at 28 weeks' gestation or later. The women in the triple-drug arm continued the drugs until breastfeeding ceased, but those in the zidovudine/single-dose nevirapine arm did not receive postnatal prophylaxis. Although the rate of postnatal transmission was significantly lower in the triple-drug arm than in the zidovudine/single-dose nevirapine arm without postnatal prophylaxis, the rates of transmission at birth were similar in women randomized to a triple-drug regimen (1.8%) and women randomized to antepartum zidovudine/single-dose nevirapine (2.5%); for women with CD4-cell counts from 350 to 500 cells/mm$^3$, the rate of infection at birth was 1.7% in each arm.[16] However, the study was not powered to address equivalence between regimens in preventing *in utero* infection in women with higher CD4-cell counts and the drugs in both arms were administered antepartum for only 6 weeks.

Regimens that do not include maternal ARV prophylaxis during pregnancy have been evaluated because some women may lack antenatal care and present for prenatal care for the first time when they go into labor.

Regimens that include only intrapartum and postpartum drug administration also have been shown to be effective in reducing perinatal transmission.[3-5] However, without continued infant post-exposure prophylaxis, intrapartum pre-exposure prophylaxis alone with nucleoside reverse transcriptase inhibitor drugs (zidovudine/lamivudine) is not effective in reducing transmission.[4] The SAINT trial demonstrated that intrapartum/postpartum zidovudine/lamivudine and single-dose intrapartum/newborn nevirapine are similar in efficacy and safety.[5]

*Combination infant ARV prophylaxis is recommended in the United States for infants whose mothers have not received antenatal ARV drugs.*

In some situations, it may be impossible to administer maternal antepartum and intrapartum therapy and only infant prophylaxis may be an option. In the absence of maternal therapy, the standard infant prophylaxis regimen of 6 weeks of zidovudine was effective in reducing HIV transmission compared with no prophylaxis, based on epidemiologic data in resource-rich countries.[17] A trial in Malawi in breastfeeding infants demonstrated that adding 1 week of zidovudine therapy to infant single-dose nevirapine reduced risk of transmission by 36% compared with infant single-dose nevirapine alone.[6]

To define the optimal infant prophylaxis regimen in the absence of maternal antepartum ARV drug administration in a formula-fed population of infants such as in the United States, the NICHD-HPTN 040/P1043 (NCT00099359) multicountry (Argentina, Brazil, South Africa, and the United States) clinical trial enrolled 1,735 formula-fed infants born to HIV-infected mothers who did not receive ARV drugs during the current pregnancy before labor (if women presented early enough, intravenous intrapartum zidovudine was given).[18] The study compared 3 infant ARV regimens: standard 6 weeks of zidovudine alone versus 6 weeks of zidovudine plus 3 doses of nevirapine given in the first week of life (first dose birth to 48 hours; second dose 48 hours after first dose; third dose 96 hours after second dose) versus 6 weeks of zidovudine plus lamivudine and nelfinavir given from birth through age 2 weeks. The study demonstrated that the combination regimens reduced risk of intrapartum transmission by approximately 50% compared with infant prophylaxis with zidovudine alone (see Table 3). Based on these data, combination ARV prophylaxis is now recommended in the United States for infants whose mothers have not received antenatal ARV drugs (see Infant Antiretroviral Prophylaxis).

*Adding single-dose intrapartum nevirapine is not recommended for women in the United States who are receiving standard recommended antenatal ARV prophylaxis.*

Several studies in formula-fed and breastfed populations in resource-limited countries have found that adding maternal/infant single-dose nevirapine to a maternal short-course zidovudine or zidovudine/lamivudine regimen increased efficacy compared with the short-course regimen alone.[14, 19, 20] Whether single-dose nevirapine provides any additional efficacy when combined with the standard recommended combination ARV prophylaxis regimens used in the United States was evaluated in PACTG 316, a clinical trial conducted in the United States, Europe, Brazil, and the Bahamas. This study demonstrated that for nonbreastfeeding women in resource-rich countries, the addition of single-dose nevirapine did not offer significant benefit in the setting of combination ARV prophylaxis throughout pregnancy and very low viral load at the time of delivery.[21] Thus, adding single-dose intrapartum nevirapine is not recommended for women in the United States who are receiving standard recommended antenatal ARV prophylaxis (see Intrapartum Care).

*Breastfeeding by HIV-infected women is not recommended in the United States.*

Breastfeeding by HIV-infected women (including those receiving ARV drugs) is not recommended in the United States where replacement feeding is affordable, feasible, acceptable, sustainable, and safe and the risk of infant mortality due to diarrheal and respiratory infections is low. A number of studies have evaluated the use of maternal or infant ARV prophylaxis during breastfeeding to reduce postnatal transmission (see Table 3). Observational data and randomized clinical trials have demonstrated that infant prophylaxis (primarily

using daily infant nevirapine) during breastfeeding significantly decreases risk of postnatal transmission in breast milk and that maternal triple-drug prophylaxis during breastfeeding likewise decreases postnatal infection.[1, 16, 22-27] Maternal prophylaxis with triple-drug regimens may be less effective than infant prophylaxis when the maternal triple regimen is first started postpartum or late in pregnancy because it takes several weeks to months before full viral suppression in breast milk is achieved.[26, 28] Importantly, although significantly lowering the risk of postnatal infection, neither infant nor maternal postpartum ARV prophylaxis completely eliminates the risk of HIV transmission through breast milk. Therefore, breastfeeding is not recommended for HIV-infected women in the United States (including those receiving combination ARV drug regimens). Finally, both infant nevirapine prophylaxis and maternal triple-drug prophylaxis during breastfeeding may be associated with development of ARV drug resistance in infants who become infected despite prophylaxis.[29-32] Three studies have found multiclass drug resistance in breastfeeding infants who became infected despite maternal triple-drug prophylaxis.[30-33]

**Table 3. Results of Major Studies on Antiretroviral Prophylaxis to Prevent Mother-to-Child Transmission of HIV (page 1 of 9)**

| Study Location(s) Mode of Infant Feeding | Antiretroviral (ARV) Drugs | Antepartum and Intrapartum | Postpartum | Mother-to-Child Transmission (MTCT) Rate and Efficacy |
|---|---|---|---|---|
| PACTG 076<br>United States, France[34]<br>Formula feeding | ZDV vs. placebo | Long (from 14 weeks)<br>IV IP | Long (6 weeks), infant only | • MTCT at 18 months was 8.3% in ZDV arm vs. 25.5% in placebo arm (68% efficacy). |
| CDC short-course ZDV trial<br>Thailand[11]<br>Formula feeding | ZDV vs. placebo | Short (from 36 weeks)<br>Oral IP | None | • MTCT at 6 months was 9.4% in ZDV arm vs. 18.9% in placebo arm (50% efficacy). |
| DITRAME (ANRS 049a) trial<br>Ivory Coast, Burkina Faso[10, 35]<br>Breastfeeding | ZDV vs. placebo | Short (from 36 weeks)<br>Oral IP | Short (1 week), mother only | • MTCT was 18.0% in ZDV arm vs. 27.5% in placebo arm at 6 months (38% efficacy) and 21.5% vs. 30.6% at 15 months (30% efficacy).<br>• MTCT was 22.5% in ZDV arm vs. 30.2% in placebo arm in pooled analysis at 24 months (26% efficacy). |
| CDC short-course ZDV trial<br>Ivory Coast[9, 10]<br>Breastfeeding | ZDV vs. placebo | Short (from 36 weeks)<br>Oral IP | None | • MTCT was 16.5% in ZDV arm vs. 26.1% in placebo arm at 3 months (37% efficacy).<br>• MTCT was 22.5% in ZDV arm vs. 30.2% in placebo arm in pooled analysis at 24 months (26% efficacy). |

**Table 3. Results of Major Studies on Antiretroviral Prophylaxis to Prevent Mother-to-Child Transmission of HIV (page 2 of 9)**

| Study Location(s) Mode of Infant Feeding | Antiretroviral (ARV) Drugs | Antepartum and Intrapartum | Postpartum | Mother-to-Child Transmission (MTCT) Rate and Efficacy |
|---|---|---|---|---|
| PETRA trial<br>South Africa, Tanzania, and Uganda[4]<br>Breastfeeding and formula feeding | AP/IP/PP ZDV + 3TC vs. IP/PP ZDV + 3TC vs. IP-only ZDV + 3TC vs. placebo | Short (from 36 weeks)<br>Oral IP | Short (1 week), mother and infant | • MTCT was 5.7% at 6 weeks for AP/IP/PP ZDV + 3TC, 8.9% for IP/PP ZDV + 3TC, 14.2% for IP-only ZDV + 3TC, and 15.3% for placebo (efficacy compared with placebo: 63%, 42%, and 0%, respectively).<br>• MTCT was 14.9% at 18 months for AP/IP/PP ZDV + 3TC, 18.1% for IP/PP ZDV + 3TC, 20.0% for IP-only ZDV + 3TC, and 22.2% for placebo (efficacy compared with placebo: 34%, 18%, and 0%, respectively). |
| HIVNET 012 trial Uganda[3]<br>Breastfeeding | sdNVP vs. ZDV | No AP ARV<br>Oral IP: sdNVP vs. oral ZDV | sdNVP within 72 hours of birth, infant only vs. ZDV (1 week), infant only | • MTCT was 11.8% in NVP arm vs. 20.0% in ZDV arm at 6–8 weeks (42% efficacy); 15.7% in NVP arm vs. 25.8% in ZDV arm at 18 months (41% efficacy). |
| SAINT trial<br>South Africa[5]<br>Breastfeeding and formula feeding | sdNVP vs. ZDV + 3TC | No AP ARV<br>Oral IP: sdNVP vs. ZDV + 3TC | sdNVP within 48 hours of birth, mother and infant vs. ZDV + 3TC (1 week), mother and infant | • MTCT was 12.3% in sdNVP arm vs. 9.3% in ZDV + 3TC arm at 8 weeks (difference not statistically significant, $P = 0.11$). |
| Perinatal HIV Prevention Trial (PHPT-1)<br>Thailand[12]<br>Formula feeding | Four ZDV regimens with different durations of AP and infant PP administration, no placebo | Long (from 28 weeks), short (from 36 weeks)<br>Oral IP | Long (6 weeks), short (3 days), infant only | • Short-short arm stopped at interim analysis (10.5%). MTCT was 6.5% in long-long arm vs. 4.7% in long-short arm and 8.6% in short-long arm at 6 months (no statistical difference). *In utero* transmission was significantly higher with short vs. long maternal therapy regimens (5.1% vs. 1.6%). |

**Table 3. Results of Major Studies on Antiretroviral Prophylaxis to Prevent Mother-to-Child Transmission of HIV (page 3 of 9)**

| Study Location(s) Mode of Infant Feeding | Antiretroviral (ARV) Drugs | Antepartum and Intrapartum | Postpartum | Mother-to-Child Transmission (MTCT) Rate and Efficacy |
|---|---|---|---|---|
| PACTG 316 trial Bahamas, Belgium, Brazil, France, Germany, Italy, Spain, Sweden, Switzerland, United Kingdom, United States[21]<br>Formula feeding | sdNVP vs. placebo among women already receiving ZDV alone (23%) or ZDV + other ARV drugs (77% combination therapy) | Nonstudy ARV regimen<br>Oral IP: placebo vs. sdNVP + IV ZDV | Placebo vs. sdNVP within 72 hours of birth + nonstudy ARV drugs (ZDV), infant only | • 77% of women received dual- or triple-combination ARV regimens during pregnancy.<br>• Trial stopped early because of very low MTCT in both arms: 1.4% in sdNVP arm vs. 1.6% in placebo arm (53% of MTCT was *in utero*). |
| Perinatal HIV Prevention Trial (PHPT-2)<br>Thailand[19]<br>Formula feeding | ZDV alone vs. ZDV + maternal and infant sdNVP vs. ZDV + maternal sdNVP | ZDV from 28 weeks<br>Oral IP: ZDV alone or ZDV + sdNVP | ZDV for 1 week with or without sdNVP, infant only | • ZDV-alone arm was stopped because of higher MTCT than the NVP-NVP arm (6.3% vs. 1.1%). In arms in which the mother received sdNVP, MTCT rate did not differ significantly between the infant receiving or not receiving sdNVP (2.0% vs. 2.8%). |
| DITRAME Plus (ANRS 1201.0) trial<br>Ivory Coast[14]<br>Breastfeeding and formula feeding | Open label, ZDV + sdNVP | ZDV from 36 weeks<br>Oral IP: ZDV plus sdNVP | sdNVP + ZDV for 1 week, infant only | • MTCT was 6.5% (95% CI, 3.9%–9.1%) at 6 weeks; MTCT for historical control group receiving short ZDV (98% breastfed) was 12.8%. |
| DITRAME Plus (ANRS 1201.1) trial<br>Ivory Coast[14]<br>Breastfeeding and formula feeding | Open label, ZDV + 3TC + sdNVP | ZDV + 3TC from 32 weeks (stopped at 3 days PP)<br>Oral IP: ZDV + 3TC + sdNVP | sdNVP + ZDV for 1 week, infant only | • MTCT was 4.7% (95% CI, 2.4%–7.0%) at 6 weeks; MTCT for historical control group receiving short ZDV (98% breastfed) was 12.8%. |
| NVAZ trial<br>Malawi[6]<br>Breastfeeding | Neonatal sdNVP vs. sdNVP + ZDV | No AP or IP ARV (latecomers) | sdNVP with or without ZDV for 1 week, infant only | • MTCT was 15.3% in sdNVP + ZDV arm and 20.9% in sdNVP-only arm at 6–8 weeks. MTCT rate at 6–8 weeks among infants who were HIV uninfected at birth was 7.7% and 12.1%, respectively (36% efficacy). |
| Postnatal NVP + ZDV trial<br>Malawi[7]<br>Breastfeeding | Neonatal sdNVP vs. sdNVP + ZDV | No AP ARV<br>Oral IP: sdNVP | sdNVP with or without ZDV for 1 week, infant only | • MTCT was 16.3% in NVP + ZDV arm and 14.1% in sdNVP-only arm at 6–8 weeks (difference not statistically significant). MTCT rate at 6–8 weeks among infants who were HIV uninfected at birth was 6.5% and 16.9%, respectively. |

**Table 3. Results of Major Studies on Antiretroviral Prophylaxis to Prevent Mother-to-Child Transmission of HIV (page 4 of 9)**

| Study Location(s) Mode of Infant Feeding | Antiretroviral (ARV) Drugs | Antepartum and Intrapartum | Postpartum | Mother-to-Child Transmission (MTCT) Rate and Efficacy |
|---|---|---|---|---|
| Post-exposure Infant Prophylaxis<br>South Africa[8]<br>Breastfeeding and formula feeding | Neonatal sdNVP vs. ZDV for 6 weeks | No AP or IP ARV | sdNVP vs. ZDV for 6 weeks | • For formula-fed infants only, MTCT was 14.3% in sdNVP arm vs. 14.1% in ZDV arm at 6 weeks (not significant, $P$ = 0.30). For breastfed infants only, MTCT was 12.2% in sdNVP arm and 19.6% in ZDV arm ($P$ = 0.03). |
| Mashi<br>Botswana[20, 36]<br>Breastfeeding and formula feeding | Initial: short-course ZDV with/without maternal and infant sdNVP and with/without breastfeeding<br><br>Revised: short-course ZDV + infant sdNVP with/without maternal sdNVP and with/without breastfeeding; women with CD4 T-lymphocyte (CD4-cell) counts <200 cells/mm$^3$ receive combination therapy | 1st randomization<br><br>ZDV from 34 weeks<br><br>Oral IP: ZDV + either sdNVP vs. placebo | 2nd randomization<br><br>Breastfeeding + ZDV (infant) 6 months + sdNVP, infant only<br><br>vs.<br><br>Formula feeding + ZDV (infant) 4 weeks + sdNVP, infant only | • Initial design: In formula-feeding arm, MTCT at 1 month was 2.4% in maternal and infant sdNVP arm and 8.3% in placebo arm ($P$ = 0.05). In breastfeeding + infant ZDV arm, MTCT at 1 month was 8.4% in sdNVP arm and 4.1% in placebo arm (difference not statistically significant).<br><br>• Revised design: MTCT at 1 month was 4.3% in maternal + infant sdNVP arm and 3.7% in maternal placebo + infant sdNVP arm (no significant difference; no interaction with mode of infant feeding).<br><br>• MTCT at 7 months was 9.1% in breastfeeding + ZDV arm and 5.6% in formula-feeding arm; mortality at 7 months was 4.9% in breastfeeding + ZDV arm vs. 9.3% in formula-feeding arm; HIV-free survival at 18 months was 15.6% breastfeeding + ZDV arm vs. 14.2% formula-feeding arm. |

**Table 3. Results of Major Studies on Antiretroviral Prophylaxis to Prevent Mother-to-Child Transmission of HIV (page 5 of 9)**

| Study Location(s) Mode of Infant Feeding | Antiretroviral (ARV) Drugs | Antepartum and Intrapartum | Postpartum | Mother-to-Child Transmission (MTCT) Rate and Efficacy |
|---|---|---|---|---|
| SWEN<br>Uganda, Ethiopia, India[23]<br>Breastfeeding | sdNVP vs. NVP for 6 weeks | No AP ARV<br>Oral IP: sdNVP | Infant sdNVP vs. NVP for 6 weeks | • Postnatal infection in infants uninfected at birth:<br>- MTCT at 6 weeks was 5.3% in sdNVP arm vs. 2.5% in extended NVP arm (risk ratio 0.54, $P = 0.009$).<br>- MTCT at 6 months was 9.0% in sdNVP arm vs. 6.9% in extended NVP arm (risk ratio 0.80, $P = 0.16$).<br>• HIV-free survival was significantly lower in extended NVP arm at both 6 weeks and 6 months of age. |
| PEPI-Malawi Trial<br>Malawi[22]<br>Breastfeeding | sdNVP + ZDV for 1 week (control) vs. two extended infant regimens (NVP or NVP/ZDV) for 14 weeks | No AP ARV<br>Oral IP: sdNVP (if mother presents in time) | Infant sdNVP + ZDV for 1 week (control) vs. control + NVP for 14 weeks vs. control + NVP/ZDV for 14 weeks | • Postnatal infection in infants uninfected at birth:<br>- MTCT at age 6 weeks was 5.1% in control vs. 1.7% in extended NVP (67% efficacy) and 1.6% in extended NVP/ZDV arms (69% efficacy).<br>- MTCT at age 9 months was 10.6% in control vs. 5.2% in extended NVP (51% efficacy) and 6.4% in extended NVP/ZDV arms (40% efficacy).<br>• No significant difference in MTCT between the extended prophylaxis arms; however, more hematologic toxicity with NVP/ZDV. |
| MITRA<br>Tanzania[25]<br>Breastfeeding | Infant 3TC for 6 months (observational) | ZDV/3TC from 36 weeks through labor | Maternal ZDV/3TC for 1 week; infant 3TC for 6 months | • MTCT at age 6 months was 4.9% (postnatal MTCT between ages 6 weeks and 6 months was 1.2%). |

**Table 3. Results of Major Studies on Antiretroviral Prophylaxis to Prevent Mother-to-Child Transmission of HIV (page 6 of 9)**

| Study Location(s) Mode of Infant Feeding | Antiretroviral (ARV) Drugs | Antepartum and Intrapartum | Postpartum | Mother-to-Child Transmission (MTCT) Rate and Efficacy |
|---|---|---|---|---|
| Kisumu Breastfeeding Study (KiBS) Kenya[27] Breastfeeding | Maternal triple-drug prophylaxis (observational) | ZDV/3TC/NVP (NFV if CD4-cell count >250 cells/mm$^3$) from 34 weeks through labor | Maternal ZDV/3TC/NVP (NFV if CD4-cell count >250 cells/mm$^3$) for 6 months; infant sdNVP | • MTCT at age 6 months was 5.0% (postnatal MTCT between ages 7 days and 6 months was 2.6%). |
| MITRA-PLUS Tanzania[24] Breastfeeding | Maternal triple-drug prophylaxis (observational) | ZDV/3TC/NVP (NFV if CD4-cell count >200 cells/mm$^3$) from 34 weeks through labor | Maternal ZDV/3TC/NVP (NFV if CD4-cell count >200 cells/mm$^3$) for 6 months; infant ZDV/3TC for 1 week | • MTCT at age 6 months was 5.0% (postnatal MTCT between ages 6 weeks and 6 months was 0.9%), not significantly different from 6 months infant prophylaxis in MITRA. |
| Kesho Bora Multi-African[16] Breastfeeding primarily | Antepartum ZDV/sdNVP with no postnatal prophylaxis vs. maternal triple-drug prophylaxis in women with CD4-cell counts of 200–500 cells/mm$^3$ | Arm 1: ZDV/3TC/LPV/r<br>Arm 2: ZDV + sdNVP<br>From 28 weeks through labor | Arm 1: Maternal ZDV/3TC/LPV/r for 6 months; infant sdNVP + ZDV for 1 week<br>Arm 2: Maternal ZDV/3TC for 1 week (no further postnatal prophylaxis); infant sdNVP + ZDV for 1 week (no further postnatal prophylaxis) | • MTCT at birth was 1.8% with maternal triple-drug prophylaxis Arm 1 and 2.5% with ZDV/sdNVP Arm 2, not significantly different. In women with CD4-cell counts 350–500 cells/mm$^3$, MTCT at birth was 1.7% in both arms.<br>• MTCT at age 12 months was 5.4% with maternal triple-drug prophylaxis Arm 1 and 9.5% with ZDV/sdNVP (with no further postnatal prophylaxis after 1 week) Arm 2 ($P$ = 0.029). |
| Mma Bana Botswana[1] Breastfeeding | Maternal triple-drug prophylaxis (compares 2 regimens) in women with CD4-cell counts >200 cells/mm$^3$ | Arm 1: ZDV/3TC/ABC<br>Arm 2: ZDV/3TC/LPV/r<br>From 26 weeks through labor | Arm 1: Maternal ZDV/3TC/ABC for 6 months; infant sdNVP + ZDV for 4 weeks<br>Arm 2: Maternal ZDV/3TC/LPV/r for 6 months; infant sdNVP + ZDV for 4 weeks | • MTCT at age 6 months overall was 1.3%: 2.1% in ZDV/3TC/ABC Arm 1 and 0.4% in ZDV/3TC/LPV/r Arm 2 ($P$ = 0.53). |

**Table 3. Results of Major Studies on Antiretroviral Prophylaxis to Prevent Mother-to-Child Transmission of HIV (page 7 of 9)**

| Study Location(s) Mode of Infant Feeding | Antiretroviral (ARV) Drugs | Antepartum and Intrapartum | Postpartum | Mother-to-Child Transmission (MTCT) Rate and Efficacy |
|---|---|---|---|---|
| BAN<br>Malawi[26, 37]<br>Breastfeeding | Postpartum maternal triple-drug prophylaxis vs. infant NVP in women with CD4-cell counts ≥250 cells/mm$^3$ | No AP drugs<br><br>IP regimens:<br><br>Arm 1 (control): ZDV/3TC + sdNVP<br><br>Arm 2: ZDV/3TC + sdNVP<br><br>Arm 3: ZDV/3TC + sdNVP | Arm 1 (control): Maternal ZDV/3TC for 1 week; infant sdNVP + ZDV/3TC for 1 week<br><br>Arm 2: Control as above, then maternal ZDV/3TC/LPV/r for 6 months<br><br>Arm 3: Control as above, then infant NVP for 6 months | • Postnatal infection in infants uninfected at age 2 weeks:<br><br>- MTCT at age 28 weeks was 5.7% in control Arm 1; 2.9% in maternal triple-drug prophylaxis Arm 2 ($P$ = 0.009 vs. control); 1.7% in infant NVP Arm 3 ($P$ <0.001 vs. control).<br><br>- MTCT at age 48 weeks was 7.0% in control Arm 1; 4% in maternal triple-drug prophylaxis Arm 2 ($P$ = 0.0273 vs. control); 4% in infant NVP Arm 3 ($P$ = 0.0027 vs. control).<br><br>• No significant difference between maternal triple-drug prophylaxis Arm 2 and infant NVP Arm 3 ($P$ = 0.12 at 28 weeks and $P$ = 0.426 at 48 weeks). |

**Table 3. Results of Major Studies on Antiretroviral Prophylaxis to Prevent Mother-to-Child Transmission of HIV (page 8 of 9)**

| Study Location(s) Mode of Infant Feeding | Antiretroviral (ARV) Drugs | Antepartum and Intrapartum | Postpartum | Mother-to-Child Transmission (MTCT) Rate and Efficacy |
|---|---|---|---|---|
| HPTN 046<br>South Africa, Tanzania, Uganda, Zimbabwe[33]<br>Breastfeeding | Postpartum prophylaxis of breast milk transmission of HIV with 6 weeks vs. 6 months of infant NVP | AP drugs allowed if required for maternal health | All infants received daily NVP from birth through age 6 weeks.<br><br>Arm 1: Daily infant NVP from 6 weeks through 6 months of age<br><br>Arm 2: Daily infant placebo from 6 weeks through age 6 months of age | • In infants uninfected at age 6 weeks, the 6-month infant HIV infection rate was 1.1% (0.3%–1.8%) in the extended NVP Arm 1 and 2.4% (1.3%–3.6%) in the placebo Arm 2 ($P = 0.048$).<br><br>• At infant randomization at age 6 weeks, 29% of mothers in each arm were receiving a triple-drug ARV regimen for treatment of HIV.<br><br>• For mothers receiving triple-drug ARV regimens at the time of randomization, in infants uninfected at age 6 weeks, the 6-month infant HIV infection rate was 0.2% and not statistically different between extended NVP Arm 1 (0.5%) and placebo Arm 2 (0%).<br><br>• For mothers with CD4-cell counts >350 cells/mm$^3$ who were not receiving triple-drug ARV regimens, in infants uninfected at age 6 weeks, the 6-month infant HIV infection rate was 0.7% (0%–1.5%) in the extended NVP Arm 1 and 2.8% (1.3%–4.4%) in the placebo Arm 2 ($P = 0.014$). |

**Table 3. Results of Major Studies on Antiretroviral Prophylaxis to Prevent Mother-to-Child Transmission of HIV (page 9 of 9)**

| Study Location(s) Mode of Infant Feeding | Antiretroviral (ARV) Drugs | Antepartum and Intrapartum | Postpartum | Mother-to-Child Transmission (MTCT) Rate and Efficacy |
|---|---|---|---|---|
| NICHD-HPTN 040/PACTG 1043 trial<br>Argentina, Brazil, South Africa, United States[18]<br>Formula feeding | Infant prophylaxis with 6 weeks ZDV vs. 6 weeks infant ZDV plus three doses of NVP in first week of life vs. 6 weeks infant ZDV plus 2 weeks of 3TC/NFV | No AP drugs<br>If mother presented early enough, IV ZDV during labor through delivery | Arm 1 (control): Infant ZDV for 6 weeks<br>Arm 2: Control as above plus NVP with first dose within 48 hours of birth, second dose 48 hours later, and third dose 96 hours after the second dose<br>Arm 3: Control as above, plus 3TC and NFV from birth through 2 weeks of age | • IP HIV transmission among infants with negative HIV test at birth: 4.8% (3.2%–7.1%) ZDV (Arm 1) vs. 2.2% (1.2%–3.9%) in ZDV plus NVP (Arm 2) ($P$ = 0.046 compared with Arm 1) vs. 2.4% (1.4%–4.3%) in ZDV plus 3TC/NFV (Arm 3) ($P$ = 0.046 compared with Arm 1).<br>• Overall HIV transmission rates, including *in utero* infection: 11.0% (8.7%–14.0%) ZDV (Arm 1) vs. 7.1% (5.2%–9.6%) in ZDV plus NVP (Arm 2) ($P$ = 0.035 compared with Arm 1) vs. 7.4% (5.4%–9.9%) in ZDV plus 3TC/NFV (Arm 3) ($P$ = 0.035 compared with Arm 1).<br>• Grade 3 or 4 neutropenia more frequent in ZDV/3TC/NFV Arm 3, 70 infants, compared with ZDV alone Arm 1, 33 infants, or ZDV/NVP Arm 2, 32 infants ($P$ <0.001). |

**Key to Abbreviations:** 3TC = lamivudine, ABC = abacavir, AP = antepartum, ARV = antiretroviral, CDC = Centers for Disease Control and Prevention, CI = confidence interval, IP = intrapartum, IV = intravenous, LPV/r = lopinavir/ritonavir, MTCT = mother-to-child transmission, NFV = nelfinavir, NVP = nevirapine, PP = postpartum, sd = single-dose, ZDV = zidovudine

## References


1. Shapiro RL, Hughes MD, Ogwu A, et al. Antiretroviral regimens in pregnancy and breast-feeding in Botswana. *N Engl J Med*. Jun 17 2010;362(24):2282-2294. Available at http://www.ncbi.nlm.nih.gov/pubmed/20554983.
2. Kesho Bora Study Group. Eighteen-month follow-up of HIV-1-infected mothers and their children enrolled in the Kesho Bora study observational cohorts. *J Acquir Immune Defic Syndr*. Aug 2010;54(5):533-541. Available at http://www.ncbi.nlm.nih.gov/pubmed/20543706.
3. Jackson JB, Musoke P, Fleming T, et al. Intrapartum and neonatal single-dose nevirapine compared with zidovudine for prevention of mother-to-child transmission of HIV-1 in Kampala, Uganda: 18-month follow-up of the HIVNET 012 randomised trial. *Lancet*. Sep 13 2003;362(9387):859-868. Available at http://www.ncbi.nlm.nih.gov/pubmed/13678973.
4. Petra Study Team. Efficacy of three short-course regimens of zidovudine and lamivudine in preventing early and late transmission of HIV-1 from mother to child in Tanzania, South Africa, and Uganda (Petra study): a randomised, double-blind, placebo-controlled trial. *Lancet*. Apr 6 2002;359(9313):1178-1186. Available at http://www.ncbi.nlm.nih.gov/pubmed/11955535.

5. Moodley D, Moodley J, Coovadia H, et al. A multicenter randomized controlled trial of nevirapine versus a combination of zidovudine and lamivudine to reduce intrapartum and early postpartum mother-to-child transmission of human immunodeficiency virus type 1. *J Infect Dis*. Mar 1 2003;187(5):725-735. Available at http://www.ncbi.nlm.nih.gov/pubmed/12599045.

6. Taha TE, Kumwenda NI, Gibbons A, et al. Short postexposure prophylaxis in newborn babies to reduce mother-to-child transmission of HIV-1: NVAZ randomised clinical trial. *Lancet*. Oct 11 2003;362(9391):1171-1177. Available at http://www.ncbi.nlm.nih.gov/pubmed/14568737.

7. Taha TE, Kumwenda NI, Hoover DR, et al. Nevirapine and zidovudine at birth to reduce perinatal transmission of HIV in an African setting: a randomized controlled trial. *JAMA*. Jul 14 2004;292(2):202-209. Available at http://www.ncbi.nlm.nih.gov/pubmed/15249569.

8. Gray GE, Urban M, Chersich MF, et al. A randomized trial of two postexposure prophylaxis regimens to reduce mother-to-child HIV-1 transmission in infants of untreated mothers. *AIDS*. Aug 12 2005;19(12):1289-1297. Available at http://www.ncbi.nlm.nih.gov/pubmed/16052084.

9. Wiktor SZ, Ekpini E, Karon JM, et al. Short-course oral zidovudine for prevention of mother-to-child transmission of HIV-1 in Abidjan, Cote d'Ivoire: a randomised trial. *Lancet*. Mar 6 1999;353(9155):781-785. Available at http://www.ncbi.nlm.nih.gov/pubmed/10459958.

10. Leroy V, Karon JM, Alioum A, et al. Twenty-four month efficacy of a maternal short-course zidovudine regimen to prevent mother-to-child transmission of HIV-1 in West Africa. *AIDS*. Mar 8 2002;16(4):631-641. Available at http://www.ncbi.nlm.nih.gov/pubmed/11873008.

11. Shaffer N, Chuachoowong R, Mock PA, et al. Short-course zidovudine for perinatal HIV-1 transmission in Bangkok, Thailand: a randomised controlled trial. Bangkok Collaborative Perinatal HIV Transmission Study Group. *Lancet*. Mar 6 1999;353(9155):773-780. Available at http://www.ncbi.nlm.nih.gov/pubmed/10459957.

12. Lallemant M, Jourdain G, Le Coeur S, et al. A trial of shortened zidovudine regimens to prevent mother-to-child transmission of human immunodeficiency virus type 1. Perinatal HIV Prevention Trial (Thailand) Investigators. *N Engl J Med*. Oct 5 2000;343(14):982-991. Available at http://www.ncbi.nlm.nih.gov/pubmed/11018164.

13. Leroy V, Sakarovitch C, Cortina-Borja M, et al. Is there a difference in the efficacy of peripartum antiretroviral regimens in reducing mother-to-child transmission of HIV in Africa? *AIDS*. Nov 4 2005;19(16):1865-1875. Available at http://www.ncbi.nlm.nih.gov/pubmed/16227795.

14. Dabis F, Bequet L, Ekouevi DK, et al. Field efficacy of zidovudine, lamivudine and single-dose nevirapine to prevent peripartum HIV transmission. *AIDS*. Feb 18 2005;19(3):309-318. Available at http://www.ncbi.nlm.nih.gov/pubmed/15718842.

15. Townsend CL, Cortina-Borja M, Peckham CS, de Ruiter A, Lyall H, Tookey PA. Low rates of mother-to-child transmission of HIV following effective pregnancy interventions in the United Kingdom and Ireland, 2000-2006. *AIDS*. May 11 2008;22(8):973-981. Available at http://www.ncbi.nlm.nih.gov/pubmed/18453857.

16. Kesho Bora Study Group, de Vincenzi I. Triple antiretroviral compared with zidovudine and single-dose nevirapine prophylaxis during pregnancy and breastfeeding for prevention of mother-to-child transmission of HIV-1 (Kesho Bora study): a randomised controlled trial. *Lancet Infect Dis*. Mar 2011;11(3):171-180. Available at http://www.ncbi.nlm.nih.gov/pubmed/21237718.

17. Wade NA, Birkhead GS, Warren BL, et al. Abbreviated regimens of zidovudine prophylaxis and perinatal transmission of the human immunodeficiency virus. *N Engl J Med*. Nov 12 1998;339(20):1409-1414. Available at http://www.ncbi.nlm.nih.gov/pubmed/9811915.

18. Nielsen-Saines K, Watts DH, Veloso VG, et al. Three postpartum antiretroviral regimens to prevent intrapartum HIV infection. *N Engl J Med*. June 21 2012;366(25):2368-79. Available at http://www.ncbi.nlm.nih.gov/pubmed/27716975.

19. Lallemant M, Jourdain G, Le Coeur S, et al. Single-dose perinatal nevirapine plus standard zidovudine to prevent mother-to-child transmission of HIV-1 in Thailand. *N Engl J Med*. Jul 15 2004;351(3):217-228. Available at http://www.ncbi.nlm.nih.gov/pubmed/15247338.

20. Shapiro RL, Thior I, Gilbert PB, et al. Maternal single-dose nevirapine versus placebo as part of an antiretroviral strategy to prevent mother-to-child HIV transmission in Botswana. *AIDS*. Jun 12 2006;20(9):1281-1288. Available at http://www.ncbi.nlm.nih.gov/pubmed/16816557.

21. Dorenbaum A, Cunningham CK, Gelber RD, et al. Two-dose intrapartum/newborn nevirapine and standard antiretroviral therapy to reduce perinatal HIV transmission: a randomized trial. *JAMA*. Jul 10 2002;288(2):189-198. Available at http://www.ncbi.nlm.nih.gov/pubmed/12095383.

22. Kumwenda NI, Hoover DR, Mofenson LM, et al. Extended antiretroviral prophylaxis to reduce breast-milk HIV-1 transmission. *N Engl J Med*. Jul 10 2008;359(2):119-129. Available at http://www.ncbi.nlm.nih.gov/pubmed/18525035.

23. Six Week Extended-Dose Nevirapine Study Team, Bedri A, Gudetta B, et al. Extended-dose nevirapine to 6 weeks of age for infants to prevent HIV transmission via breastfeeding in Ethiopia, India, and Uganda: an analysis of three randomised controlled trials. *Lancet*. Jul 26 2008;372(9635):300-313. Available at http://www.ncbi.nlm.nih.gov/pubmed/18657709.

24. Kilewo C, Karlsson K, Ngarina M, et al. Prevention of mother-to-child transmission of HIV-1 through breastfeeding by treating mothers with triple antiretroviral therapy in Dar es Salaam, Tanzania: the Mitra Plus study. *J Acquir Immune Defic Syndr*. Nov 1 2009;52(3):406-416. Available at http://www.ncbi.nlm.nih.gov/pubmed/19730269.

25. Kilewo C, Karlsson K, Massawe A, et al. Prevention of mother-to-child transmission of HIV-1 through breast-feeding by treating infants prophylactically with lamivudine in Dar es Salaam, Tanzania: the Mitra Study. *J Acquir Immune Defic Syndr*. Jul 1 2008;48(3):315-323. Available at http://www.ncbi.nlm.nih.gov/pubmed/18344879.

26. Chasela CS, Hudgens MG, Jamieson DJ, et al. Maternal or infant antiretroviral drugs to reduce HIV-1 transmission. *N Engl J Med*. Jun 17 2010;362(24):2271-2281. Available at http://www.ncbi.nlm.nih.gov/pubmed/20554982.

27. Thomas TK, Masaba R, Borkowf CB, et al. Triple-antiretroviral prophylaxis to prevent mother-to-child HIV transmission through breastfeeding—the Kisumu Breastfeeding Study, Kenya: a clinical trial. *PLoS Med*. Mar 2011;8(3):e1001015. Available at http://www.ncbi.nlm.nih.gov/pubmed/21468300.

28. Mofenson LM. Protecting the next generation—eliminating perinatal HIV-1 infection. *N Engl J Med*. Jun 17 2010;362(24):2316-2318. Available at http://www.ncbi.nlm.nih.gov/pubmed/20554987.

29. Moorthy A, Gupta A, Bhosale R, et al. Nevirapine resistance and breast-milk HIV transmission: effects of single and extended-dose nevirapine prophylaxis in subtype C HIV-infected infants. *PLoS One*. 2009;4(1):e4096. Available at http://www.ncbi.nlm.nih.gov/pubmed/19119321.

30. Lidstrom J, Guay L, Musoke P, et al. Multi-class drug resistance arises frequently in HIV-infected breastfeeding infants whose mothers initiate HAART postpartum. Paper presented at: 17th Conference on Retroviruses and Opportunistic Infections (CROI); February 16-19, 2010; San Francisco, CA. Abstract 920.

31. Zeh C, Weidle PJ, Nafisa L, et al. HIV-1 drug resistance emergence among breastfeeding infants born to HIV-infected mothers during a single-arm trial of triple-antiretroviral prophylaxis for prevention of mother-to-child transmission: a secondary analysis. *PLoS Med*. Mar 2011;8(3):e1000430. Available at http://www.ncbi.nlm.nih.gov/pubmed/21468304.

32. Fogel J, Li Q, Taha TE, et al. Initiation of antiretroviral treatment in women after delivery can induce multiclass drug resistance in breastfeeding HIV-infected infants. *Clin Infect Dis*. Apr 15 2011;52(8):1069-1076. Available at http://www.ncbi.nlm.nih.gov/pubmed/21460326.

33. Coovadia HM, Brown ER, Fowler MG, et al. Efficacy and safety of an extended nevirapine regimen in infant children of breastfeeding mothers with HIV-1 infection for prevention of postnatal HIV-1 transmission (HPTN 046): a randomised, double-blind, placebo-controlled trial. *Lancet*. Jan 21 2012;379(9812):221-228. Available at http://www.ncbi.nlm.nih.gov/pubmed/22196945.

34. Connor EM, Sperling RS, Gelber R, et al. Reduction of maternal-infant transmission of human immunodeficiency virus type 1 with zidovudine treatment. Pediatric AIDS Clinical Trials Group Protocol 076 Study Group. *N Engl J Med*. Nov 3 1994;331(18):1173-1180. Available at http://www.ncbi.nlm.nih.gov/pubmed/7935654.

35. Dabis F, Msellati P, Meda N, et al. 6-month efficacy, tolerance, and acceptability of a short regimen of oral zidovudine to reduce vertical transmission of HIV in breastfed children in Cote d'Ivoire and Burkina Faso: a double-blind placebo-controlled multicentre trial. DITRAME Study Group. DIminution de la Transmission Mere-Enfant. *Lancet*. Mar 6 1999;353(9155):786-792. Available at http://www.ncbi.nlm.nih.gov/pubmed/10459959.

36. Thior I, Lockman S, Smeaton LM, et al. Breastfeeding plus infant zidovudine prophylaxis for 6 months vs formula feeding plus infant zidovudine for 1 month to reduce mother-to-child HIV transmission in Botswana: a randomized trial: the Mashi Study. *JAMA*. Aug 16 2006;296(7):794-805. Available at http://www.ncbi.nlm.nih.gov/pubmed/16905785.

37. Jamieson DJ, Chasela CS, Hudgens MG, et al. Maternal and infant antiretroviral regimens to prevent postnatal HIV-1 transmission: 48-week follow-up of the BAN randomised controlled trial. *Lancet*. Apr 25 2012. Available at http://www.ncbi.nlm.nih.gov/pubmed/22541418.

## Perinatal Transmission of HIV and Maternal HIV RNA Copy Number (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendation |
|---|
| • All HIV-infected pregnant women should be counseled about and administered antiretroviral drugs during pregnancy for prevention of perinatal transmission, regardless of their HIV RNA levels **(AI)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

Mother-to-child transmission has been observed across the entire range of plasma HIV RNA levels.[1, 2] HIV RNA levels correlate with risk of transmission even in women treated with antiretroviral (ARV) agents.[3-5] Although the risk of perinatal transmission in women with undetectable HIV RNA levels appears to be extremely low, transmission has been reported even in women with very low or undetectable levels of maternal HIV RNA on antiretroviral therapy (ART).[3-5] Additionally, although HIV RNA may be an important risk factor for transmission, other factors also appear to play a role.[6-8]

Although there is a general correlation between viral loads in plasma and in the genital tract, discordance between blood and genital tract virus has also been reported; low level cervico-vaginal HIV RNA and DNA shedding has been detected even in women treated with ART who have undetectable plasma viral load, particularly in the presence of genital tract coinfections.[9-11] Penetration of ARV drugs into the female genital tract has been shown to vary between drugs.[12-14] If exposure to HIV in the maternal genital tract during delivery is a risk factor for perinatal transmission, plasma HIV RNA levels may not always be an accurate indicator of risk. Long-term changes in one body compartment with ARV drugs may or may not be associated with comparable changes in other compartments. Additional studies are needed to determine the effect of ARV drugs on genital tract viral load and the association between such effects and the risk of perinatal transmission of HIV.

Because transmission can occur even when HIV RNA copy numbers are low or undetectable, all HIV-infected women should be counseled about and administered ARV drugs during pregnancy, regardless of their HIV RNA levels.

## References


1. Garcia PM, Kalish LA, Pitt J, et al. Maternal levels of plasma human immunodeficiency virus type 1 RNA and the risk of perinatal transmission. Women and Infants Transmission Study Group. *N Engl J Med*. Aug 5 1999;341(6):394-402. Available at http://www.ncbi.nlm.nih.gov/pubmed/10432324.
2. Mofenson LM, Lambert JS, Stiehm ER, et al. Risk factors for perinatal transmission of human immunodeficiency virus type 1 in women treated with zidovudine. Pediatric AIDS Clinical Trials Group Study 185 Team. *N Engl J Med*. Aug 5 1999;341(6):385-393. Available at http://www.ncbi.nlm.nih.gov/pubmed/10432323.
3. Warszawski J, Tubiana R, Le Chenadec J, et al. Mother-to-child HIV transmission despite antiretroviral therapy in the ANRS French Perinatal Cohort. *AIDS*. Jan 11 2008;22(2):289-299. Available at http://www.ncbi.nlm.nih.gov/pubmed/18097232.
4. Tubiana R, Le Chenadec J, Rouzioux C, et al. Factors associated with mother-to-child transmission of HIV-1 despite a maternal viral load <500 copies/ml at delivery: a case-control study nested in the French perinatal cohort (EPF-ANRS CO1). *Clin Infect Dis*. Feb 15 2010;50(4):585-596. Available at http://www.ncbi.nlm.nih.gov/pubmed/20070234.

5. European Collaborative Study. Mother-to-child transmission of HIV infection in the era of highly active antiretroviral therapy. *Clin Infect Dis*. Feb 1 2005;40(3):458-465. Available at http://www.ncbi.nlm.nih.gov/pubmed/15668871.

6. Maternal viral load and vertical transmission of HIV-1: an important factor but not the only one. The European Collaborative Study. *AIDS*. Jul 30 1999;13(11):1377-1385. Available at http://www.ncbi.nlm.nih.gov/pubmed/10449292.

7. Mock PA, Shaffer N, Bhadrakom C, et al. Maternal viral load and timing of mother-to-child HIV transmission, Bangkok, Thailand. Bangkok Collaborative Perinatal HIV Transmission Study Group. *AIDS*. Feb 25 1999;13(3):407-414. Available at http://www.ncbi.nlm.nih.gov/pubmed/10199232.

8. Shaffer N, Roongpisuthipong A, Siriwasin W, et al. Maternal virus load and perinatal human immunodeficiency virus type 1 subtype E transmission, Thailand. Bangkok Collaborative Perinatal HIV Transmission Study Group. *J Infect Dis*. Mar 1999;179(3):590-599. Available at http://www.ncbi.nlm.nih.gov/pubmed/9952365.

9. Launay O, Tod M, Tschope I, et al. Residual HIV-1 RNA and HIV-1 DNA production in the genital tract reservoir of women treated with HAART: the prospective ANRS EP24 GYNODYN study. *Antivir Ther*. 2011;16(6):843-852. Available at http://www.ncbi.nlm.nih.gov/pubmed/21900716.

10. Cu-Uvin S, DeLong AK, Venkatesh KK, et al. Genital tract HIV-1 RNA shedding among women with below detectable plasma viral load. *AIDS*. Oct 23 2010;24(16):2489-2497. Available at http://www.ncbi.nlm.nih.gov/pubmed/20736815.

11. Henning TR, Kissinger P, Lacour N, Meyaski-Schluter M, Clark R, Amedee AM. Elevated cervical white blood cell infiltrate is associated with genital HIV detection in a longitudinal cohort of antiretroviral therapy-adherent women. *J Infect Dis*. Nov 15 2010;202(10):1543-1552. Available at http://www.ncbi.nlm.nih.gov/pubmed/20925530.

12. Yeh RF, Rezk NL, Kashuba AD, et al. Genital tract, cord blood, and amniotic fluid exposures of seven antiretroviral drugs during and after pregnancy in human immunodeficiency virus type 1-infected women. *Antimicrob Agents Chemother*. Jun 2009;53(6):2367-2374. Available at http://www.ncbi.nlm.nih.gov/pubmed/19307360.

13. Dumond JB, Yeh RF, Patterson KB, et al. Antiretroviral drug exposure in the female genital tract: implications for oral pre- and post-exposure prophylaxis. *AIDS*. Sep 12 2007;21(14):1899-1907. Available at http://www.ncbi.nlm.nih.gov/pubmed/17721097.

14. Else LJ, Taylor S, Back DJ, Khoo SH. Pharmacokinetics of antiretroviral drugs in anatomical sanctuary sites: the male and female genital tract. *Antivir Ther*. 2011;16(8):1149-1167. Available at http://www.ncbi.nlm.nih.gov/pubmed/22155899.

# Preconception Counseling and Care for HIV-Infected Women of Childbearing Age

## Overview (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendations |
|---|
| • Discuss childbearing intentions with all women of childbearing age on an ongoing basis throughout the course of their care **(AIII)**.<br>• Include information about effective and appropriate contraceptive methods to reduce the likelihood of unintended pregnancy **(AI)**.<br>• During preconception counseling, include information on safer sexual practices and elimination of alcohol, illicit drugs, and smoking, which are important for the health of all women as well as for fetal/infant health, should pregnancy occur **(AII)**.<br>• When evaluating HIV-infected women, include assessment of HIV disease status and need for antiretroviral therapy (ART) for their own health **(AII)**.<br>• Choose an ART regimen for HIV-infected women of childbearing age based on consideration of effectiveness for treatment of maternal disease, hepatitis B virus disease status, teratogenic potential of the drugs in the regimen should pregnancy occur, and possible adverse outcomes for mother and fetus **(AII)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*<br>***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

The Centers for Disease Control and Prevention (CDC), the American College of Obstetricians and Gynecologists, and other national organizations recommend offering all women of childbearing age comprehensive family planning and the opportunity to receive preconception counseling and care as a component of routine primary medical care. The purpose of preconception care is to improve the health of each woman before conception by identifying risk factors for adverse maternal or fetal outcome, providing education and counseling targeted to patients' individual needs, and treating or stabilizing medical conditions to optimize maternal and fetal outcomes.[1] Preconception care is not a single clinical visit but, rather, a process of ongoing care and interventions integrated into primary care to address the needs of women during the different stages of reproductive life. Because more than half of all pregnancies in the United States are unintended[2-5] it is important that comprehensive family planning and preconception care be integrated into routine health visits. Providers should initiate and document a nonjudgmental conversation with all women of reproductive age concerning their reproductive desires because women may be reluctant to bring this up themselves.[6, 7] HIV care providers who routinely care for women of reproductive age play an important role in promoting preconception health and informed reproductive decisions.

The fundamental principles of preconception counseling and care are outlined in the CDC Preconception Care Work Group's *Recommendations to Improve Preconception Health and Health Care*. In addition to the general components of preconception counseling and care that are appropriate for all women of reproductive age, HIV-infected women have specific needs that should be addressed.[8, 9] Because many women infected with HIV are aware of their HIV status before becoming pregnant, issues that impact pregnancy can be addressed before conception during their routine medical care for HIV disease. In addition to the principles outlined by the CDC Preconception Care Work Group[10], the following components of preconception

counseling and care are specifically recommended for HIV-infected women. Health care providers should:

a. Discuss reproductive options; actively assess women's pregnancy intentions on an ongoing basis throughout the course of care; and, when appropriate, make referrals to experts in HIV and women's health, including experts in reproductive endocrinology and infertility when necessary.[11, 12]
b. Offer all women effective and appropriate contraceptive methods to reduce the likelihood of unintended pregnancy. Providers should be aware of potential interactions between antiretroviral (ARV) drugs and hormonal contraceptives that could lower contraceptive efficacy (see Table 4).
c. Counsel on safe sexual practices that prevent HIV transmission to sexual partners, protect women from acquiring sexually transmitted diseases, and reduce the potential to acquire more virulent or resistant strains of HIV.
d. Counsel on eliminating alcohol, illicit drug use, and cigarette smoking.
e. Educate and counsel women about risk factors for perinatal transmission of HIV, strategies to reduce those risks, potential effects of HIV or of ARV drugs given either for treatment or solely for prevention of mother-to-child transmission (MTCT) on pregnancy course and outcomes, and the recommendation that HIV-infected women in the United States not breastfeed because of the risk of transmission of HIV and the availability of safe and sustainable infant feeding alternatives.
f. When prescribing antiretroviral therapy (ART) to women of childbearing age, consider the regimen's effectiveness for treatment of HIV, an individual's hepatitis B disease status, the drugs' potential for teratogenicity should pregnancy occur, and possible adverse outcomes for mother and fetus.[13-15]
g. Use the preconception period in women who are contemplating pregnancy to adjust ARV regimens to exclude efavirenz or other drugs with teratogenic potential.
h. Make a primary treatment goal for women who are on ART for their own health and who want to get pregnant the attainment of a stable, maximally suppressed maternal viral load prior to conception to decrease the risk of MTCT.
i. Evaluate and appropriately manage therapy-associated side effects such as hyperglycemia, anemia, and hepatotoxicity that may adversely impact maternal-fetal health outcomes.
j. Evaluate the need for appropriate prophylaxis or treatment for opportunistic infections, including safety, tolerability, and potential toxicity of specific agents when used in pregnancy.
k. Administer medical immunizations for influenza, pneumococcal or hepatitis A and B vaccines, and other vaccines as indicated (see http://www.cdc.gov/vaccines/recs/acip/rec-vac-preg.htm and http://www.cdc.gov/vaccines/recs/acip/downloads/preg-principles05-01-08.pdf).
l. Encourage sexual partners to receive HIV testing and, if infected, to seek counseling and appropriate HIV care.

## Table 4: Drug Interactions Between Antiretroviral Agents and Hormonal Contraceptives (page 1 of 2)

Data on drug interactions between antiretroviral (ARV) agents and hormonal contraceptives primarily come from drug labels and the clinical implications have not been well studied. The magnitude of changes in contraceptive drug levels that may reduce contraceptive efficacy or increase contraceptive-associated adverse effects is unknown. Hormonal contraceptives can be used with antiretroviral therapy (ART) in women without other contraindications. Additional or alternative methods of contraception may be recommended when drug interactions are known.

| Antiretroviral Drug | Effect on Drug Levels | Dosing Recommendation/ Clinical Comment |
|---|---|---|
| **Non-nucleoside Reverse Transcriptase Inhibitor (NNRTI)** | | |
| Efavirenz (EFV) | Oral ethinyl estradiol/norgestimate: No effect on ethinyl estradiol concentrations; ↓ active metabolites of norgestimate (levonorgestrel AUC ↓83%; norelgestromin AUC ↓64%) | A reliable method of barrier contraception must be used in addition to hormonal contraceptives. Efavirenz had no effect on ethinyl estradiol concentrations, but progestin levels (norelgestromin and levonorgestrel) were markedly decreased. No effect of ethinyl estradiol/norgestimate on efavirenz plasma concentrations was observed. |
| | Implant: ↓ etonogestrel | A reliable method of barrier contraception must be used in addition to hormonal contraceptives. The interaction between etonogestrel and efavirenz has not been studied. Decreased exposure of etonogestrel may be expected. In postmarketing reports, contraceptive failure with etonogestrel has been noted in efavirenz-exposed patients. |
| | Levonorgestrel AUC ↓58% | Effectiveness of emergency postcoital contraception may be diminished. |
| Etravirine (ETR) | Ethinyl estradiol AUC ↑22%<br>Norethindrone: no significant effect | No dosage adjustment needed. |
| Nevirapine (NVP) | Ethinyl estradiol AUC ↓20%<br>Norethindrone AUC ↓19% | Additional methods recommended; alternative methods can be considered. |
| | DMPA: no significant change | No dosage adjustment needed. |
| Rilpivirine (RPV) | Ethinyl estradiol AUC ↑14%<br>Norethindrone: no significant change | No dose adjustment needed. |
| **Ritonavir (RTV)-boosted Protease Inhibitor (PI)** | | |
| Atazanavir/ritonavir (ATV/r) | ↓ Ethinyl estradiol<br>↑ Norgestimate | Oral contraceptive should contain ≥35 mcg ethinyl estradiol. Oral contraceptives containing progestins other than norethindrone or norgestimate have not been studied. |

## Table 4: Drug Interactions Between Antiretroviral Agents and Hormonal Contraceptives (page 2 of 2)

| Antiretroviral Drug | Effect on Drug Levels | Dosing Recommendation/ Clinical Comment |
|---|---|---|
| Darunavir/ritonavir (DRV/r) | Ethinyl estradiol AUC ↓44%<br>Norethindrone AUC ↓14% | Additional methods recommended; alternative methods can be considered. |
| Fosamprenavir/ritonavir (FPV/r) | Ethinyl estradiol AUC ↓37%<br>Norethindrone AUC ↓34% | Alternative methods of nonhormonal contraception are recommended. |
| Lopinavir/ritonavir (LPV/r) | Ethinyl estradiol AUC ↓42%<br>Norethindrone AUC ↓17% | Additional methods recommended; alternative methods can be considered. |
| Saquinavir/ritonavir (SQV/r) | ↓Ethinyl estradiol | Additional methods recommended; alternative methods can be considered. |
| Tipranavir/ritonavir (TPV/r) | Ethinyl estradiol AUC ↓48%<br>Norethindrone: no significant change | Additional methods recommended; alternative methods can be considered. |
| **PI without RTV** | | |
| Atazanavir (ATV) | Ethinyl estradiol AUC ↑48%<br>Norethindrone AUC ↑110% | Oral contraceptive should contain ≤30 mcg of ethinyl estradiol or use alternative method. Oral contraceptives containing <25 mcg ethinyl estradiol or progestins other than norethindrone or norgestimate have not been studied. |
| Fosamprenavir (FPV) | Amprenavir: ↑ Ethinyl estradiol and ↑ norethindrone<br>Fosamprenavir with ethinyl estradiol/norethindrone:<br>↓ Amprenavir (AUC 22%, $C_{min}$ 20%) | Use alternative method.<br>Use of fosamprenavir alone with ethinyl estradiol/norethindrone may lead to loss of virologic response. |
| Indinavir (IDV) | Ethinyl estradiol AUC ↑25%<br>Norethindrone AUC ↑26% | No dose adjustment needed. |
| Nelfinavir (NFV) | Ethinyl estradiol AUC ↓47%<br>Norethindrone AUC ↓18% | Additional methods recommended; alternative methods may be considered. |
| **CCR5 Antagonist** | | |
| Maraviroc (MVC) | No significant effect on ethinyl estradiol or levonorgestrel | No dose adjustment needed. |
| **Integrase Inhibitor** | | |
| Raltegravir (RAL) | No significant effect | No dose adjustment needed. |

**Key to Abbreviations:** AUC = area under the curve, $C_{min}$ = minimum plasma concentration, DMPA = depot medroxyprogesterone acetate

**Table 4 derived from:** Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents. Department of Health and Human Services. Available at http://aidsinfo.nih.gov/contentfiles/lvguidelines/AdultandAdolescentGL.pdf. Tables 15a, 15b, and 15d. Accessed June 7, 2012.

## References


1. American College of Obstetricians and Gynecologists. ACOG Committee Opinion number 313, September 2005. The importance of preconception care in the continuum of women's health care. *Obstet Gynecol*. Sep 2005;106(3):665-666. Available at http://www.ncbi.nlm.nih.gov/pubmed/16135611.
2. Johnson K, Posner SF, Biermann J, et al. Recommendations to improve preconception health and health care--United States. A report of the CDC/ATSDR Preconception Care Work Group and the Select Panel on Preconception Care. *MMWR Recomm Rep*. Apr 21 2006;55(RR-6):1-23. Available at http://www.ncbi.nlm.nih.gov/pubmed/16617292.
3. Cohn SE, Umbleja T, Mrus J, Bardeguez AD, Andersen JW, Chesney MA. Prior illicit drug use and missed prenatal vitamins predict nonadherence to antiretroviral therapy in pregnancy: adherence analysis A5084. *AIDS Patient Care STDS*. Jan 2008;22(1):29-40. Available at http://www.ncbi.nlm.nih.gov/pubmed/18442305.
4. Finer LB, Zolna MR. Unintended pregnancy in the United States: incidence and disparities 2006, pub August 25, 2011. *Contraception*. 2011. Available at http://www.contraceptionjournal.org/article/S0010-7824(11)00472-0/abstract.
5. Elgalib A, Hegazi A, Samarawickrama A, et al. Pregnancy in HIV-infected teenagers in London. *HIV Med*. Feb 2011;12(2):118-123. Available at http://www.ncbi.nlm.nih.gov/pubmed/20807252.
6. Finocchario-Kessler S, Dariotis JK, Sweat MD, et al. Do HIV-infected women want to discuss reproductive plans with providers, and are those conversations occurring? *AIDS Patient Care STDS*. May 2010;24(5):317-323. Available at http://www.ncbi.nlm.nih.gov/pubmed/20482467.
7. Finocchario-Kessler S, Sweat MD, Dariotis JK, et al. Childbearing motivations, pregnancy desires, and perceived partner response to a pregnancy among urban female youth: does HIV-infection status make a difference? *AIDS Care*. 2012;24(1):1-11. Available at http://www.ncbi.nlm.nih.gov/pubmed/21777077.
8. Lampe MA. Human immunodeficiency virus-1 and preconception care. *Matern Child Health J*. Sep 2006;10(5 Suppl):S193-195. Available at http://www.ncbi.nlm.nih.gov/pubmed/16832609.
9. Aaron EZ, Criniti SM. Preconception health care for HIV-infected women. *Top HIV Med*. Aug-Sep 2007;15(4):137-141. Available at http://www.ncbi.nlm.nih.gov/pubmed/17721000.
10. Centers for Disease Control and Prevention. Incorporating HIV prevention into the medical care of persons living with HIV. Recommendations of CDC, the Health Resources and Services Administration, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. *MMWR Recomm Rep*. Jul 18 2003;52(RR-12):1-24. Available at http://www.ncbi.nlm.nih.gov/pubmed/12875251.
11. Gosselin JT, Sauer MV. Life after HIV: examination of HIV serodiscordant couples' desire to conceive through assisted reproduction. *AIDS Behav*. Feb 2011;15(2):469-478. Available at http://www.ncbi.nlm.nih.gov/pubmed/20960049.
12. Finocchario-Kessler S, Sweat MD, Dariotis JK, et al. Understanding high fertility desires and intentions among a sample of urban women living with HIV in the United States. *AIDS Behav*. Oct 2010;14(5):1106-1114. Available at http://www.ncbi.nlm.nih.gov/pubmed/19908135.
13. Cotter AM, Garcia AG, Duthely ML, Luke B, O'Sullivan MJ. Is antiretroviral therapy during pregnancy associated with an increased risk of preterm delivery, low birth weight, or stillbirth? *J Infect Dis*. May 1 2006;193(9):1195-1201. Available at http://www.ncbi.nlm.nih.gov/pubmed/16586354.
14. Tuomala RE, Shapiro DE, Mofenson LM, et al. Antiretroviral therapy during pregnancy and the risk of an adverse outcome. *N Engl J Med*. Jun 13 2002;346(24):1863-1870. Available at http://www.ncbi.nlm.nih.gov/pubmed/12063370.
15. Stek AM. Antiretroviral medications during pregnancy for therapy or prophylaxis. *Curr HIV/AIDS Rep*. May 2009;6(2):68-76. Available at http://www.ncbi.nlm.nih.gov/pubmed/19358777.

## Reproductive Options for HIV-Concordant and Serodiscordant Couples (Last updated July 31, 2012; last reviewed July 31, 2012)

### Panel's Recommendations

- For serodiscordant couples who want to conceive, expert consultation is recommended so that approaches can be tailored to specific needs, which may vary from couple to couple **(AIII)**. It is important to recognize that treatment of the infected partner may not be fully protective against sexual transmission of HIV.
- Partners should be screened and treated for genital tract infections before attempting to conceive **(AII)**.
- For HIV-infected females with HIV-uninfected male partners, the safest conception option is artificial insemination, including the option of self-insemination with a partner's sperm during the peri-ovulatory period **(AIII)**.
- For HIV-infected men with HIV-uninfected female partners, the use of sperm preparation techniques coupled with either intrauterine insemination or *in vitro* fertilization should be considered if using donor sperm from an HIV-uninfected male is unacceptable **(AII)**.
- For serodiscordant couples who want to conceive, initiation of antiretroviral therapy (ART) for the HIV-infected partner is recommended (**AI** for CD4 T-lymphocyte (CD4-cell) count ≤550 cells/mm$^3$, **BIII** for CD4-cell count >550 cells/mm$^3$). If therapy is initiated, maximal viral suppression is recommended before conception is attempted **(AIII)**.
- Periconception administration of antiretroviral pre-exposure prophylaxis (PrEP) for HIV-uninfected partners may offer an additional tool to reduce the risk of sexual transmission **(CIII)**. The utility of PrEP of the uninfected partner when the infected partner is receiving ART has not been studied.

***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*

***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion*

For serodiscordant couples who want to conceive, expert consultation is recommended so that approaches can be tailored to specific needs, which may vary from couple to couple.

Before attempting to conceive, both partners should be screened for genital tract infections. If any such infections are identified, they should be treated because genital tract inflammation is associated with genital tract shedding of HIV.[1, 2] Semen analysis is recommended for HIV-infected males before conception is attempted because HIV, and possibly antiretroviral therapy (ART), may be associated with a higher prevalence of semen abnormalities such as low sperm count, low motility, higher rate of abnormal forms, and low semen volume. If such abnormalities are present, the uninfected female partner may be exposed unnecessarily and for prolonged periods to her partner's infectious genital fluids when the likelihood of getting pregnant naturally is low or even nonexistent.[3-6]

Observational studies have demonstrated a decreased rate of transmission of HIV in heterosexual serodiscordant couples among whom the index partners were on ART compared with those not on therapy.[7-9] HPTN 052 is a randomized clinical trial designed to evaluate whether immediate versus delayed initiation of ART by HIV-infected individuals with CD4 T-lymphocyte (CD4-cell) counts of 350 to 550 cells/mm$^3$ could prevent sexual transmission of HIV among serodiscordant couples. Most of the participants were from Africa (54%), with 30% from Asia and 16% from North and South America. Data from this study showed that earlier initiation of ART led to a significant reduction in transmission of HIV to the uninfected partner. Of 28 cases of HIV infection documented to be genetically linked to the infected partner, 27 occurred in the 877 couples in which the HIV-infected partner delayed initiation of ART until the CD4-cell count fell below 250 cells/mm$^3$, whereas only 1 case of HIV infection occurred in the 886 couples with an HIV-infected partner

who began immediate ART; 17 of the 27 transmissions in the delayed therapy group occurred in individuals with CD4-cell counts >350 cells/mm$^3$. The majority of transmissions (82%) were observed in participants from Africa. These are the first data from a randomized trial to demonstrate that provision of treatment to infected individuals can reduce the risk of transmission to their uninfected sexual partners.[10] Based on the results from HPTN 052, initiation of ART would be recommended for the infected partner in a serodiscordant couple who has a CD4-cell count of ≤550 cells/mm$^3$ if the couple wishes to conceive. Initiation of ART is also recommended for HIV-infected individuals with CD4-cell counts >550 cells/mm$^3$, although the benefit of ART in reducing sexual transmission from individuals with higher CD4-cell counts has not been determined. Before conception is attempted, maximal viral suppression is recommended for individuals who are on ART for their own health and those who do not require therapy but opt to start ART to prevent sexual transmission.

It is important to recognize that no single method (including treatment of the infected partner) is fully protective against transmission of HIV. Effective ART that decreases plasma viral load to undetectable levels is also associated with decreased concentration of virus in genital secretions. In a prospective study of 2,521 African HIV-infected serodiscordant couples, higher genital HIV RNA concentrations were associated with greater risk of heterosexual HIV-1 transmission and this effect was independent of plasma HIV concentrations. Each $\log_{10}$ increase in genital HIV-1 RNA levels increased the risk of female-to-male or male-to-female HIV transmission by 1.7-fold.[11] Discordance between plasma and genital viral loads has been reported, and individuals with an undetectable plasma viral load may have detectable genital tract virus.[12-14] In addition, antiretroviral (ARV) drugs vary in their ability to penetrate the genital tract.[15] Thus, maximal plasma viral suppression may not completely eliminate risk of heterosexual transmission. Although use of ART may not eliminate all risk of sexual transmission, it may contribute to lowering risk in couples who have decided to conceive through unprotected intercourse despite known risks.

Reducing the risk of perinatal transmission is another potential rationale for starting ART before conception in HIV-infected women who do not yet need treatment for their own health. Data suggest that early and sustained control of HIV viral replication may be associated with decreasing residual risk of perinatal transmission,[16, 17] but that does not completely eliminate the risk of perinatal transmission.[17] In addition, reports are mixed on the possible effects of combination ARV drug regimens on prematurity and low birth weight, with some but not all data suggesting that such outcomes may be more frequent in women on ARV drugs at conception[18, 19] (see Special Considerations Regarding the Use of Antiretroviral Drugs by HIV-Infected Pregnant Women and Their Infants).

The implications of initiating therapy before conception solely for prevention of sexual and/or perinatal transmission should be discussed with patients. These issues include willingness and ability to commit to potential lifelong therapy, the potential risks versus benefits of stopping or continuing the regimen after conception in the male or postpartum in the female, and the need for strict adherence to achieve maximal viral suppression. Consultation with an expert in HIV care is strongly recommended.

For HIV-discordant couples in which the female is the HIV-infected partner, the safest form of conception is artificial insemination, including the option to self-inseminate with the partner's sperm during the peri-ovulatory period. Condom use should be advised at all times.

For HIV-discordant couples in which the male is the HIV-infected partner, the use of sperm preparation techniques coupled with either intrauterine insemination or *in vitro* fertilization has been reported to be effective in avoiding seroconversion in uninfected women and offspring in several studies.[20, 21] The National Perinatal HIV Hotline (1-888-448-8765) is a resource for a list of institutions offering reproductive services for HIV-serodiscordant couples. More data are needed to demonstrate the complete efficacy of these techniques, and couples should be cautioned about the potential risk of transmission of HIV to the uninfected partner and to their offspring.[21] Discordant couples who do not have access to assisted reproduction services

and who still want to try to conceive after comprehensive counseling should be advised that timed, peri-ovulatory unprotected intercourse after the infected partner has achieved maximal viral suppression (with use of condoms at all other times) may reduce but not completely eliminate the risk of sexual transmission.[21] Uninfected women who become pregnant should be regularly counseled regarding consistent condom use to decrease their risk of sexual transmission of HIV and the possible risk of perinatal transmission (see Monitoring of HIV Uninfected Pregnant Women with a Partner Known to be HIV Infected).

Periconception pre-exposure prophylaxis (PrEP) may offer an additional option in the future to minimize risk of transmission of HIV within discordant couples. PrEP is use of ARV medications by an HIV-uninfected individual to maintain blood and genital drug levels sufficient to prevent acquisition of HIV. An experimental 1% tenofovir gel used intravaginally both before and after sex reduced the incidence of HIV infection in women by up to 54% in a randomized, placebo-controlled trial conducted in South Africa.[22] This product is not available commercially, and additional trials are needed to confirm these findings. Five efficacy trials of PrEP with oral ARV agents (primarily tenofovir alone) have been completed or are currently under way.[23] In one study of daily tenofovir/emtricitabine in HIV-seronegative men who have sex with men, there was a 44% reduction in the risk of acquisition of HIV compared with placebo.[24, 25] The TDF2 study, a placebo-controlled trial of PrEP to prevent sexual transmission in HIV-uninfected, heterosexual, sexually active, healthy adults aged 18 to 39 years in Botswana, found that daily oral PrEP with tenofovir/emtricitabine taken by the HIV-uninfected partner reduced the risk of acquisition of HIV by 63% (95% confidence interval [CI], 21.5–83.4; $P = .0133$) and was effective in both men and women.[26] The Partners PrEP Study, a placebo-controlled, three-arm trial, also found that daily PrEP with tenofovir or tenofovir/emtricitabine significantly reduced HIV transmission in discordant heterosexual couples in Kenya and Uganda. Those who received tenofovir had 62% fewer HIV infections (95% CI, 34–78; $P = .0003$) and those who received tenofovir/emtricitabine had 73% fewer HIV infections (95% CI, 49–85; $P = <.0001$) than those who received placebo, and these regimens were effective in both men and women.[27] However, the FEM-PrEP clinical trial, designed to study whether HIV-uninfected women at high risk of being exposed to HIV can safely use a daily dose of tenofovir/emtricitabine to prevent infection, was stopped early by its Data and Safety Monitoring Board (DSMB) because it was highly unlikely the study would be able to demonstrate the effectiveness of tenofovir/emtricitabine in preventing HIV infection in the study population. The approximate rate of new HIV infections among trial participants was 5% per year. A total of 56 new HIV infections had occurred, with an equal number of infections in participants assigned to tenofovir/emtricitabine and those assigned to a placebo.[28] The VOICE study is the first trial to evaluate both daily oral (tenofovir or tenofovir/emtricitabine) and topical (1% tenofovir microbicide gel) PrEP and has enrolled more than 5,000 HIV-uninfected heterosexual women in South Africa, Uganda, and Zimbabwe. The oral tenofovir and tenofovir gel arms of the study were stopped by its DSMB because it concluded that the study would be unable to show any difference between a daily dose of oral tenofovir or tenofovir gel and placebo in preventing HIV infection. The tenofovir/emtricitabine study arm is ongoing. Data on the FEM-PrEP, TDF2, Partners PrEP, and VOICE studies are preliminary.

Several studies evaluating the efficacy of PrEP in heterosexual discordant couples planning pregnancy are ongoing but complete data are not yet available. One study evaluated timed intercourse with PrEP in 46 heterosexual HIV-discordant couples with an HIV-uninfected female partner. The male HIV-infected partners were receiving ART and had undetectable plasma HIV RNA levels. One dose of oral tenofovir was taken by the women at luteinizing hormone peak and a second oral dose was taken 24 hours later. None of the women became HIV infected and pregnancy rates were high, reaching a plateau of 75% after 12 attempts.[29]

The use of daily oral PrEP during pregnancy and lactation for HIV-uninfected women with HIV-infected partners has had limited study. PrEP may offer an additional strategy for safer conception. However, it will be important to have outcome studies that examine adverse events, including risk of congenital abnormalities. Additionally, the utility of daily oral PrEP when the HIV-infected partner is receiving ART has

not been studied. If clinicians elect to use PrEP for HIV-uninfected women or men in serodiscordant couples, the couples should be educated about the potential risks and benefits and all available alternatives for safer conception. Only combination tenofovir/emtricitabine is being evaluated in current heterosexual PrEP trials. Laboratory testing for HIV infection, baseline renal function, and hepatitis B virus (HBV) infection should be performed before initiating PrEP. Screening for sexually transmitted diseases also is recommended. Individuals receiving PrEP should be monitored for potential side effects such as renal dysfunction and clinical toxicities. They should be educated about symptoms associated with acute HIV infection and advised to contact their providers immediately for further evaluation should symptoms occur. HIV-uninfected partners should undergo frequent HIV testing to detect HIV infection quickly. Should HIV infection be documented, the ARV agents should be discontinued to minimize selection of drug-resistant virus, and measures should be instituted to prevent perinatal transmission if pregnancy occurs. Individuals with chronic HBV should be monitored for possible hepatitis flares when PrEP is stopped.[30] Clinicians are strongly encouraged to register uninfected women who become pregnant while receiving PrEP with the Antiretroviral Pregnancy Registry.

### *Monitoring of HIV-Uninfected Pregnant Women with Partners Known to Be HIV Infected*

Clinicians may increasingly be seeing HIV-uninfected women who present during pregnancy and indicate that their partners are HIV infected. They, like all pregnant women, should be notified that HIV screening is recommended and they will receive an HIV test as part of the routine panel of prenatal tests unless they decline. These women also should receive a second HIV test during the third trimester, preferably before 36 weeks of gestation, as is recommended for high-risk women. Furthermore, pregnant women who present in labor without results of third-trimester testing should be screened with a rapid HIV test on the labor and delivery unit. If at any time during pregnancy a clinician suspects that a pregnant woman may be in the "window" period of seroconversion (that is, she has signs or symptoms consistent with acute HIV infection), then a plasma HIV RNA test should be used in conjunction with an HIV antibody test. If the plasma HIV RNA is negative, it should be repeated in 2 weeks. All HIV-uninfected pregnant women with HIV-infected partners should always use condoms during sexual intercourse to prevent acquisition of HIV. Women should be counseled regarding the symptoms of acute retroviral syndrome (that is, fever, pharyngitis, rash, myalgia, arthralgia, diarrhea, headache) and the importance of seeking medical care and testing if they experience such symptoms.

Women who test positive on either conventional or rapid HIV tests should receive appropriate evaluation and interventions to reduce perinatal transmission of HIV, including immediate initiation of appropriate ARV prophylaxis and consideration of elective cesarean delivery according to established guidelines (see Transmission and Mode of Delivery). In cases where confirmatory test results are not readily available, such as with rapid testing during labor, it is still appropriate to initiate interventions to reduce perinatal transmission (see Infant Antiretroviral Prophylaxis).

Women with HIV-infected partners who test HIV negative should continue to be regularly counseled regarding consistent condom use to decrease their risk of sexual transmission of HIV. Women with primary HIV infection during pregnancy or lactation are at high risk of transmitting HIV to their infants.[31, 32]

## References


1. Mitchell C, Hitti J, Paul K, et al. Cervicovaginal shedding of HIV type 1 is related to genital tract inflammation independent of changes in vaginal microbiota. *AIDS Res Hum Retroviruses*. Jan 2011;27(1):35-39. Available at http://www.ncbi.nlm.nih.gov/pubmed/20929397.
2. Johnson LF, Lewis DA. The effect of genital tract infections on HIV-1 shedding in the genital tract: a systematic review and meta-analysis. *Sex Transm Dis*. Nov 2008;35(11):946-959. Available at

http://www.ncbi.nlm.nih.gov/pubmed/18685546.

3. Garrido N, Meseguer M, Remohi J, Simon C, Pellicer A. Semen characteristics in human immunodeficiency virus (HIV)- and hepatitis C (HCV)-seropositive males: predictors of the success of viral removal after sperm washing. *Hum Reprod*. Apr 2005;20(4):1028-1034. Available at http://www.ncbi.nlm.nih.gov/pubmed/15608027.
4. Dulioust E, Du AL, Costagliola D, et al. Semen alterations in HIV-1 infected men. *Hum Reprod*. Aug 2002;17(8):2112-2118. Available at http://www.ncbi.nlm.nih.gov/pubmed/12151446.
5. Cardona-Maya W, Velilla P, Montoya CJ, Cadavid A, Rugeles MT. Presence of HIV-1 DNA in spermatozoa from HIV-positive patients: changes in the semen parameters. *Curr HIV Res*. Jul 2009;7(4):418-424. Available at http://www.ncbi.nlm.nih.gov/pubmed/19601777.
6. Bujan L, Sergerie M, Moinard N, et al. Decreased semen volume and spermatozoa motility in HIV-1-infected patients under antiretroviral treatment. *J Androl*. May-Jun 2007;28(3):444-452. Available at http://www.ncbi.nlm.nih.gov/pubmed/17215546.
7. Donnell D, Baeten JM, Kiarie J, et al. Heterosexual HIV-1 transmission after initiation of antiretroviral therapy: a prospective cohort analysis. *Lancet*. Jun 12 2010;375(9731):2092-2098. Available at http://www.ncbi.nlm.nih.gov/pubmed/20537376.
8. Del Romero J, Castilla J, Hernando V, Rodriguez C, Garcia S. Combined antiretroviral treatment and heterosexual transmission of HIV-1: cross sectional and prospective cohort study. *BMJ*. 2010;340:c2205. Available at http://www.ncbi.nlm.nih.gov/pubmed/20472675.
9. Lu W, Zeng G, Luo J, et al. HIV transmission risk among serodiscordant couples: a retrospective study of former plasma donors in Henan, China. *J Acquir Immune Defic Syndr*. Oct 1 2010;55(2):232-238. Available at http://www.ncbi.nlm.nih.gov/pubmed/21423851.
10. Cohen MS, Chen YQ, McCauley M, et al. Prevention of HIV-1 infection with early antiretroviral therapy. *N Engl J Med*. Aug 11 2011;365(6):493-505. Available at http://www.ncbi.nlm.nih.gov/pubmed/21767103.
11. Baeten JM, Kahle E, Lingappa JR, et al. Genital HIV-1 RNA predicts risk of heterosexual HIV-1 transmission. *Sci Transl Med*. Apr 6 2011;3(77):77ra29. Available at http://www.ncbi.nlm.nih.gov/pubmed/21471433.
12. Cu-Uvin S, DeLong AK, Venkatesh KK, et al. Genital tract HIV-1 RNA shedding among women with below detectable plasma viral load. *AIDS*. Oct 23 2010;24(16):2489-2497. Available at http://www.ncbi.nlm.nih.gov/pubmed/20736815.
13. Sheth PM, Kovacs C, Kemal KS, et al. Persistent HIV RNA shedding in semen despite effective antiretroviral therapy. *AIDS*. Sep 24 2009;23(15):2050-2054. Available at http://www.ncbi.nlm.nih.gov/pubmed/19710596.
14. Politch JA, Mayer KH, Welles SL, et al. Highly active antiretroviral therapy does not completely suppress HIV in semen of sexually active HIV-infected men who have sex with men. *AIDS*. Mar 23 2012. Available at http://www.ncbi.nlm.nih.gov/pubmed/22441253.
15. Taylor S, Davies S. Antiretroviral drug concentrations in the male and female genital tract: implications for the sexual transmission of HIV. *Curr Opin HIV AIDS*. Jul 2010;5(4):335-343. Available at http://www.ncbi.nlm.nih.gov/pubmed/20543610.
16. Townsend CL, Cortina-Borja M, Peckham CS, de Ruiter A, Lyall H, Tookey PA. Low rates of mother-to-child transmission of HIV following effective pregnancy interventions in the United Kingdom and Ireland, 2000-2006. *AIDS*. May 11 2008;22(8):973-981. Available at http://www.ncbi.nlm.nih.gov/pubmed/18453857.
17. Tubiana R, Le Chenadec J, Rouzioux C, et al. Factors associated with mother-to-child transmission of HIV-1 despite a maternal viral load <500 copies/ml at delivery: a case-control study nested in the French perinatal cohort (EPF-ANRS CO1). *Clin Infect Dis*. Feb 15 2010;50(4):585-596. Available at http://www.ncbi.nlm.nih.gov/pubmed/20070234.
18. Kourtis AP, Schmid CH, Jamieson DJ, Lau J. Use of antiretroviral therapy in pregnant HIV-infected women and the risk of premature delivery: a meta-analysis. *AIDS*. Mar 12 2007;21(5):607-615. Available at http://www.ncbi.nlm.nih.gov/pubmed/17314523.

19. Rudin C, Spaenhauer A, Keiser O, et al. Antiretroviral therapy during pregnancy and premature birth: analysis of Swiss data. *HIV Med*. Apr 2011;12(4):228-235. Available at http://www.ncbi.nlm.nih.gov/pubmed/20726902.

20. Aberg JA, Kaplan JE, Libman H, et al. Primary care guidelines for the management of persons infected with human immunodeficiency virus: 2009 update by the HIV medicine Association of the Infectious Diseases Society of America. *Clin Infect Dis*. Sep 1 2009;49(5):651-681. Available at http://www.ncbi.nlm.nih.gov/pubmed/19640227.

21. Ethics Committee of the American Society for Reproductive M. Human immunodeficiency virus and infertility treatment. *Fertil Steril*. Jun 2010;94(1):11-15. Available at http://www.ncbi.nlm.nih.gov/pubmed/20236636.

22. Abdool Karim Q, Abdool Karim SS, Frohlich JA, et al. Effectiveness and safety of tenofovir gel, an antiretroviral microbicide, for the prevention of HIV infection in women. *Science*. Sep 3 2010;329(5996):1168-1174. Available at http://www.ncbi.nlm.nih.gov/pubmed/20643915.

23. Okwundu CI, Okoromah CA. Antiretroviral pre-exposure prophylaxis (PrEP) for preventing HIV in high-risk individuals. *Cochrane Database Syst Rev*. 2009(1):CD007189. Available at http://www.ncbi.nlm.nih.gov/pubmed/19160329.

24. Grant RM, Lama JR, Anderson PL, et al. Preexposure chemoprophylaxis for HIV prevention in men who have sex with men. *N Engl J Med*. Dec 30 2010;363(27):2587-2599. Available at http://www.ncbi.nlm.nih.gov/pubmed/21091279.

25. Michael NL. Oral preexposure prophylaxis for HIV--another arrow in the quiver? *N Engl J Med*. Dec 30 2010;363(27):2663-2665. Available at http://www.ncbi.nlm.nih.gov/pubmed/21091280.

26. Thigpen MC, Kebaabetswe PM, Paxton LA, et al. Antiretroviral Preexposure Prophylaxis for Heterosexual HIV Transmission in Botswana. *N Engl J Med*. Jul 11 2012. Available at http://www.ncbi.nlm.nih.gov/pubmed/22784038.

27. Baeten JM, Donnell D, Ndase P, et al. Antiretroviral Prophylaxis for HIV Prevention in Heterosexual Men and Women. *N Engl J Med*. Jul 11 2012. Available at http://www.ncbi.nlm.nih.gov/pubmed/22784037.

28. Van Damme L, Corneli A, Ahmed K, et al. Preexposure Prophylaxis for HIV Infection among African Women. *N Engl J Med*. Jul 11 2012. Available at http://www.ncbi.nlm.nih.gov/pubmed/22784040.

29. Vernazza PL, Graf I, Sonnenberg-Schwan U, Geit M, Meurer A. Preexposure prophylaxis and timed intercourse for HIV-discordant couples willing to conceive a child. *AIDS*. Oct 23 2011;25(16):2005-2008. Available at http://www.ncbi.nlm.nih.gov/pubmed/21716070.

30. Lampe MA, Smith DK, Anderson GJ, Edwards AE, Nesheim SR. Achieving safe conception in HIV-discordant couples: the potential role of oral preexposure prophylaxis (PrEP) in the United States. *Am J Obstet Gynecol*. Jun 2011;204(6):488 e481-488. Available at http://www.ncbi.nlm.nih.gov/pubmed/21457911.

31. Marinda ET, Moulton LH, Humphrey JH, et al. In utero and intra-partum HIV-1 transmission and acute HIV-1 infection during pregnancy: using the BED capture enzyme-immunoassay as a surrogate marker for acute infection. *Int J Epidemiol*. Aug 2011;40(4):945-954. Available at http://www.ncbi.nlm.nih.gov/pubmed/21471020.

32. Humphrey JH, Marinda E, Mutasa K, et al. Mother to child transmission of HIV among Zimbabwean women who seroconverted postnatally: prospective cohort study. *BMJ*. 2010;341:c6580. Available at http://www.ncbi.nlm.nih.gov/pubmed/21177735.

# Antepartum Care (Last updated August 7, 2012; last reviewed July 31, 2012)

## General Principles Regarding Use of Antiretroviral Drugs during Pregnancy

| Panel's Recommendations |
|---|
| • Initial evaluation of infected pregnant women should include assessment of HIV disease status and recommendations regarding initiation of antiretroviral (ARV) drugs or the need for any modification if currently receiving antiretroviral therapy (ART) **(AIII)**. The National Perinatal HIV Hotline (1-888-448-8765) provides free clinical consultation on all aspects of perinatal HIV care. |
| • Regardless of plasma HIV RNA copy number or CD4 T-lymphocyte count, all pregnant HIV-infected women should receive a combination ARV drug regimen antepartum to prevent perinatal transmission **(AI)**. A combination regimen is recommended both for women who require therapy for their own health **(AI)** and for prevention of perinatal transmission in those who do not yet require therapy **(AII)**. |
| • The known benefits and potential risks of ARV use during pregnancy should be discussed with all women **(AIII)**. |
| • ARV drug-resistance studies should be performed before starting or modifying ARV drug regimens in women whose HIV RNA levels are above the threshold for resistance testing (that is, >500 to 1,000 copies/mL) (see Antiretroviral Drug Resistance and Resistance Testing in Pregnancy) **(AIII)**. When HIV is diagnosed later in pregnancy, ART or combination ARV prophylaxis should be initiated promptly without waiting for results of resistance testing **(BIII)**. |
| • In counseling patients, the importance of adherence to their ARV regimens should be emphasized **(AII)**. |
| • Considerations regarding continuing the ARV regimen for maternal treatment after delivery are the same as in non-pregnant individuals. The pros and cons of continuing versus discontinuing ARV drugs postpartum should be discussed with women so they can make educated decisions about postpartum ARV use before delivery **(AIII)**. Those decisions should be made in consultation with the provider who will assume responsibility for the women's HIV care after delivery. |
| • Coordination of services among prenatal care providers, primary care and HIV specialty care providers, mental health and drug abuse treatment services, and public assistance programs is essential to ensure that infected women adhere to their ARV drug regimens **(AIII)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

In addition to the standard antenatal assessments for all pregnant women, the initial evaluation of those who are HIV infected should include assessment of HIV disease status and recommendations for HIV-related medical care. This initial assessment should include the following:

a. review of prior HIV-related illnesses and past CD4 T-lymphocyte (CD4-cell) counts and plasma HIV viral loads;
b. current CD4-cell count;
c. current plasma HIV RNA copy number;
d. assessment of the need for prophylaxis against opportunistic infections such as *Pneumocystis jirovecii* pneumonia and *Mycobacterium avium* complex (see *Guidelines for Prevention and Treatment of Opportunistic Infections in HIV-Infected Adults and Adolescents*)[1];

e. screening for hepatitis C virus and tuberculosis in addition to standard screening for hepatitis B virus (HBV) infection;

f. evaluation of immunization status per guidelines from the American College of Obstetricians and Gynecologists, with particular attention to hepatitis A, HBV, influenza, pneumococcus, and Tdap immunizations;[2, 3]

g. baseline complete blood cell count and renal and liver function testing;

h. HLA-B*5701 testing if abacavir use is anticipated (see Table 5);

i history of prior and current antiretroviral (ARV) drug use, including prior ARV use for prevention of perinatal transmission or treatment of HIV and history of adherence problems;

j. results of prior and current HIV ARV drug-resistance studies;

k. history of side effects or toxicities from prior ARV regimens; and

l. assessment of supportive care needs.

ARV drugs for prevention of perinatal transmission of HIV are recommended for all pregnant women, regardless of CD4-cell counts and HIV RNA levels. In general, guidelines for the use of antiretroviral therapy (ART) for the benefit of maternal health during pregnancy are the same as for women who are not pregnant, with some modifications based on concerns about specific drugs and limited experience during pregnancy with newer drugs.

Decisions regarding initiation or modification of ARV drug regimens during pregnancy include considerations regarding the benefits and risks of ARV drugs that are common to all HIV-infected adults plus those unique to pregnancy. In general, the ARV drug combinations now available are more convenient and better tolerated than regimens used previously, resulting in greater efficacy and improved adherence. During pregnancy, maternal ARV toxicities must be considered, along with the potential impact of the ARV regimen on pregnancy outcome and on fetuses and infants. Decisions about ARV drug regimens are further complicated because only limited data exist on the long-term maternal consequences of use of agents during pregnancy solely for preventing transmission. Similarly, only limited data are available on the long-term consequences to infants of *in utero* exposure to ARVs.

The known benefits and known and unknown risks of ARV drug use during pregnancy should be considered and discussed with women (see Special Considerations Regarding the Use of Antiretroviral Drugs by HIV-Infected Pregnant Women and Their Infants). Results from preclinical and animal studies and available clinical information about use of the various agents during pregnancy also should be discussed (see Supplement: Safety and Toxicity of Individual Antiretroviral Agents in Pregnancy). Potential risks of these drugs should be placed into perspective by reviewing the substantial benefits of ARV drugs for maternal health and in reducing the risk of transmission of HIV to infants. Counseling of pregnant women about ARV use should be noncoercive, and providers should help them make informed decisions regarding use of ARV drugs.

Discussions with women about initiation of ARV drug regimens should include information about:

a. maternal risk of disease progression and the benefits and risks of initiation of therapy for maternal health;

b. benefit of combination ARV regimens for preventing perinatal transmission of HIV;[4]

c. benefits of therapy for reducing sexual transmission to discordant partners when viral suppression is maintained;[5]

d. potential adverse effects of ARV drugs for mothers, fetuses, and infants, including potential interactions with other medications the women may already be receiving;

e. the limited long-term outcome data for both women who temporarily use ARV drugs during

pregnancy for prophylaxis of transmission and infants with *in utero* drug exposure; and

f. the need for strict adherence to the prescribed drug regimen to avoid resistance.

Studies of zidovudine in prevention of perinatal transmission suggest that an important mechanism of infant pre-exposure prophylaxis is transplacental drug passage. Thus, when selecting an ARV regimen for a pregnant woman, at least one nucleoside/nucleotide reverse transcriptase inhibitor (NRTI) agent with high placental transfer should be included as a component of the dual-NRTI backbone (see Table 5).[6-9]

In women with plasma HIV RNA levels above the threshold for resistance testing (that is, >500–1,000 copies/mL), ARV drug-resistance studies should be performed before starting ARV drugs for maternal health or prophylaxis. When HIV is diagnosed later in pregnancy, however, ARV drugs should be initiated promptly without waiting for results of resistance testing (see Antiretroviral Drug Resistance and Resistance Testing in Pregnancy).

Counseling should emphasize the importance of adherence to the ARV drug regimen. Support services, mental health services, and drug abuse treatment may be required, depending on women's individual circumstances. Coordination of services among prenatal care providers, primary care and HIV specialty care providers, mental health and drug abuse treatment services, and public assistance programs is essential to ensure that infected women adhere to their ARV drug regimens.

Providers should work with women to develop long-range plans regarding continuity of medical care and decisions about continuing ARV drugs postpartum. Considerations regarding postpartum continuation of ARV drugs for maternal therapeutic indications are the same as for non-pregnant individuals. The impact on short- and long-term maternal health is unknown for postpartum discontinuation of combination ARV drug regimens used solely to prevent perinatal transmission. This is particularly important because women may have multiple pregnancies resulting in episodic receipt of ARV drugs. No increase in disease progression has been seen so far, however, in studies of pregnant women with relatively high CD4-cell counts who stop combination ARV drug regimens after delivery.[10-12] The risks versus benefits of stopping ARV drug regimens postpartum in women with high CD4-cell counts are being evaluated in the ongoing PROMISE study (clinical trial number NCT00955968).

Current adult treatment guidelines strongly recommend ART for all individuals with CD4-cell counts <350 cells/mm$^3$ based on randomized, controlled clinical trial data demonstrating a clear benefit in reduction of mortality and morbidity. Pregnant women with CD4-cell counts <350 cells/mm$^3$ should begin ART as soon as possible during pregnancy and be counseled about the need to continue therapy after delivery and the importance of adherence to the regimen.

Based on observational cohort data and recent results from a randomized trial, the adult treatment guidelines also recommend initiating lifelong ART in individuals with CD4-cell counts between 350 and 500 cells/mm$^3$. Observational studies suggest a relative decrease in mortality (although the overall number of events was small) and possibly a decrease in complications such as cardiovascular events with initiation of ART in this setting compared with waiting until CD4-cell counts drop below 350 cells/mm$^3$.[13, 14] The HPTN 052 study was a large, multinational randomized trial evaluating whether treatment of HIV-infected individuals reduces transmission to their uninfected sexual partners.[5] An additional objective was to examine if ART reduced clinical events in the HIV-infected participants. This trial enrolled 1,763 HIV-infected participants with CD4-cell counts between 350 and 550 cells/mm$^3$ and their HIV-uninfected partners. The infected participants were randomized to immediate initiation of ART or delay of initiation until they had 2 consecutive CD4-cell counts <250 cells/mm$^3$. At median follow-up of 1.7 years, there were 40 events/deaths in participants assigned to immediate ART versus 65 in participants assigned to delayed initiation (hazard ratio [HR]: 0.59; 95% confidence interval [CI]: 0.40–0.88). The observed difference was driven mainly by the incidence of extrapulmonary tuberculosis (3 vs. 17 events). There was no significant difference in mortality rates

observed in the immediate versus deferred therapy arms (10 vs. 13 deaths, respectively; HR: 0.77; 95% CI: 0.34–1.76). The trial was stopped early because of a significantly reduced rate of transmission to sexual partners in the group who started therapy immediately compared with those who delayed. Of 28 transmissions that were virologically linked to the infected partner, only 1 occurred in the immediate-therapy arm (HR, 0.04; 95% CI, 0.01–0.27; $P$ <0.001).[5]

Pregnant women with CD4-cell counts between 350 and 500 cells/mm$^3$ should be started on a combination ARV regimen during pregnancy to prevent perinatal transmission of HIV and counseled about the current treatment recommendations, the potential risks versus benefits of stopping versus continuing the regimen after delivery (including reduction in transmission to discordant partners with continuing therapy when viral suppression is maintained), and the need for sustained strict adherence if the regimen is continued postpartum.

For individuals with CD4-cell counts >500 cells/mm$^3$, the adult guidelines recommend initiating lifelong therapy as a moderate recommendation, given that data are incomplete on the clinical benefit of starting treatment at higher CD4-cell counts (>500 cells/mm$^3$). So far, no increased risk of disease progression has been shown in studies of pregnant women with relatively high CD4-cell counts who stop ARV drugs after delivery.[10-12] The potential benefits of early therapy must be weighed against possible drug toxicity, cost, and the risk of development of viral resistance with suboptimal adherence, which may be more likely postpartum.[15] Pregnant women with CD4-cell counts >500 cells/mm$^3$ should be started on a combination ARV regimen during pregnancy to prevent perinatal transmission. They should be assessed for their willingness and ability to commit to ongoing continuous therapy and counseled about the current treatment guidelines, the benefits and risks of therapy, the inconclusive nature of data on the clinical benefit of starting lifelong treatment at CD4-cell counts >500 cells/mm$^3$, and the importance of adherence if the regimen is continued postpartum.

In general, when drugs are discontinued postnatally, all drugs should be stopped simultaneously. However, as discussed later (see Stopping Antiretroviral Therapy during Pregnancy), in women receiving non-nucleoside reverse transcriptase inhibitor (NNRTI)-based regimens, continuing the dual-NRTI backbone for a period of time after stopping the NNRTI is recommended to reduce the development of NNRTI resistance. An alternative strategy is to replace the NNRTI with a protease inhibitor (PI) while continuing the NRTI and then discontinue all the drugs at the same time.[16] The optimal interval between stopping an NNRTI and stopping the other ARV drugs is unknown, but a minimum of 7 days is recommended. Drug concentrations may be detectable for more than 3 weeks after efavirenz is stopped in patients receiving an efavirenz-based NNRTI regimen. Therefore, for patients receiving the drug, some experts recommend continuing the other ARV agents or substituting a PI plus two other agents for up to 30 days.

Medical care of HIV-infected pregnant women requires coordination and communication between HIV specialists and obstetrical providers. General counseling should include current knowledge about risk factors for perinatal transmission. Risk of perinatal transmission of HIV has been associated with potentially modifiable factors, including cigarette smoking, illicit drug use, genital tract infections, and unprotected sexual intercourse with multiple partners during pregnancy.[17-21] Besides improving maternal health, cessation of cigarette smoking and drug use, treatment of genital tract infections, and use of condoms with sexual intercourse during pregnancy may reduce risk of perinatal transmission. In addition, the Centers for Disease Control and Prevention recommends that HIV-infected women in the United States (including those receiving ART) refrain from breastfeeding to avoid postnatal transmission of HIV to their infants through breast milk[22] and avoid premastication of food for their infants, a potential risk factor for transmission.[23]

***The National Perinatal HIV Hotline (1-888-448-8765)***

The National Perinatal HIV Hotline is a federally funded service providing free clinical consultation to providers caring for HIV-infected women and their infants.

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 1 of 16)**

(See also Safety and Toxicity of Individual Antiretroviral Drugs in Pregnancy supplement for additional toxicity data and *Guidelines for the Use of Antiretroviral Agents in HIV-1-infected Adults and Adolescents* for detailed guidelines regarding treatment options.)

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **NRTIs** | | | NRTIs are recommended for use as part of combination regimens, usually including two NRTIs with either an NNRTI or one or more PIs. Use of single or dual NRTIs alone is not recommended for treatment of HIV infection. | | See text for discussion of potential maternal and infant mitochondrial toxicity. |
| **Preferred Agents** | | | | | |
| **Lamivudine** (3TC) Epivir | Epivir 150-, 300-mg tablets or 10-mg/mL oral solution | Epivir 150 mg BID or 300 mg once daily<br>Take without regard to meals. | Because of extensive experience with 3TC in pregnancy in combination with ZDV, 3TC plus ZDV is a recommended dual-NRTI backbone for pregnant women. | PK not significantly altered in pregnancy; no change in dose indicated.[24] High placental transfer to fetus. | No evidence of human teratogenicity (can rule out 1.5-fold increase in overall birth defects).[25] Well tolerated; short-term safety demonstrated for mothers and infants. If hepatitis B coinfected, possible hepatitis B flare if drug stopped postpartum; see Special Situations: Hepatitis B Virus Coinfection. |
| | Combivir 3TC 150 mg + ZDV 300 mg | Combivir 1 tablet BID | | | |
| | Epzicom 3TC 300 mg + ABC 600 mg | Epzicom 1 tablet once daily | | | |
| | Trizivir[c] 3TC 150 mg + ZDV 300 mg + ABC 300 mg | Trizivir 1 tablet BID | | | |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 2 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Zidovudine** (AZT, ZDV) Retrovir | Retrovir<br>100-mg capsules,<br>300-mg tablets,<br>10-mg/mL IV solution,<br>10-mg/mL oral solution | Retrovir<br>300 mg BID or<br>200 mg TID<br>Take without regard to meals. | Because of extensive experience with ZDV in pregnancy in combination with 3TC, ZDV plus 3TC is a recommended dual-NRTI backbone for pregnant women. | PK not significantly altered in pregnancy; no change in dose indicated.[26] High placental transfer to fetus. | No evidence of human teratogenicity (can rule out 1.5-fold increase in overall birth defects).[25] Well tolerated; short-term safety demonstrated for mothers and infants. |
| | Combivir<br>ZDV 300 mg +<br>3TC 150 mg | Combivir<br>1 tablet BID | | | |
| | Trizivir[c]<br>ZDV 300 mg +<br>3TC 150 mg +<br>ABC 300 mg | Trizivir<br>1 tablet BID | | | |
| **Alternative Agents** | | | | | |
| **Abacavir** (ABC) Ziagen | Ziagen<br>300-mg tablets or 20-mg/mL oral solution | Ziagen<br>300 mg BID or<br>600 mg once daily<br>Take without regard to meals. | Alternative NRTI for dual-NRTI backbone of combination regimens. See footnote regarding use in triple-NRTI regimen.[c] | PK not significantly altered in pregnancy; no change in dose indicated.[27] High placental transfer to fetus. | No evidence of human teratogenicity (can rule out 2-fold increase in overall birth defects).[25] Hypersensitivity reactions occur in ~5%–8% of non-pregnant individuals; a much smaller percentage are fatal and are usually associated with re-challenge. Rate in pregnancy unknown. Testing for HLA-B*5701 identifies patients at risk of reactions [28, 29] and should be done and documented as negative before starting ABC. Patients should be educated regarding symptoms of hypersensitivity reaction. |
| | Epzicom<br>ABC 600 mg +<br>3TC 300 mg | Epzicom<br>1 tablet once daily | | | |
| | Trizivir[c]<br>ABC 300 mg +<br>ZDV 300 mg +<br>3TC 150 mg | Trizivir<br>1 tablet BID | | | |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 3 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Alternative Agents, continued** | | | | | |
| **Emtricitabine**<br>(FTC)<br>Emtriva | Emtriva<br>200-mg capsule<br>or 10-mg/mL oral solution | Emtriva<br>200-mg capsule once daily or 240-mg (24-mL) oral solution once daily<br>Take without regard to meals. | Alternative NRTI for dual-NRTI backbone of combination regimens. | PK study shows slightly lower levels in third trimester, compared with postpartum.[30] No clear need to increase dose. High placental transfer to fetus. | No evidence of human teratogenicity (can rule out 2-fold increase in overall birth defects).[25] If hepatitis B coinfected, possible hepatitis B flare if drug stopped postpartum; see Special Situations: Hepatitis B Virus Coinfection. |
| | Truvada<br>FTC 200 mg + TDF 300 mg | Truvada<br>1 tablet once daily | | | |
| | Atripla<br>FTC 200 mg +<br>EFV[d] 600 mg +<br>TDF 300 mg | Atripla<br>1 tablet at or before bedtime<br>Take on an empty stomach to reduce side effects. | | | |
| **Tenofovir Disoproxil Fumarate**<br>(TDF)<br>Viread | Viread<br>300-mg tablet | Viread<br>1 tablet once daily<br>Take without regard to meals. | Alternative NRTI for dual-NRTI backbone of combination regimens. TDF would be a preferred NRTI in combination with 3TC or FTC in women with chronic HBV infection. Because of potential for renal toxicity, renal function should be monitored. | AUC lower in third trimester than postpartum but trough levels adequate.[31] High placental transfer to fetus.[7, 32-35] | No evidence of human teratogenicity (can rule out 2-fold increase in overall birth defects).[25] Studies in monkeys at doses approximately 2-fold higher than that for human therapeutic use show decreased fetal growth and reduction in fetal bone porosity within 2 months of starting maternal therapy.[36] Clinical studies in humans (particularly children) show bone demineralization with chronic use; clinical significance unknown.[37, 38] If hepatitis B coinfected, possible hepatitis B flare if drug stopped postpartum; see Special Situations: Hepatitis B Virus Coinfection. |
| | Truvada<br>TDF 300 mg + FTC 200 mg | Truvada<br>1 tablet once daily | | | |
| | Atripla<br>TDF 300 mg +<br>EFV[d] 600 mg +<br>FTC 200 mg | Atripla<br>1 tablet at or before bedtime<br>Take on an empty stomach to reduce side effects. | | | |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 4 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Use in Special Circumstances** | | | | | |
| **Didanosine** (ddI) Videx EC, generic didanosine (dose same as Videx EC) | Videx EC 125-, 200-, 250-, 400-mg capsules<br>Buffered tablets (non-EC) no longer available<br>Videx 10-mg/mL oral solution | **Body weight ≥60kg:** 400 mg once daily; with TDF, 250 mg once daily<br>**Body weight <60kg:** 250 mg once daily; with TDF, 200 mg once daily<br>Take 1/2 hour before or 2 hours after a meal.<br>Preferred dosing with oral solution is BID (total daily dose divided into 2 doses). | Because of the need to administer on empty stomach and potential toxicity, ddI should be used only in special circumstances where preferred or alternative NRTIs cannot be used. ddI should not be used with d4T. | PK not significantly altered in pregnancy; no change in dose indicated.[39] Moderate placental transfer to fetus. | In the APR, an increased rate of birth defects with ddI compared to general population was noted after both first trimester (19/409, 4.6%, 95% CI, 2.8–7.2) and later exposure (20/460, 4.3%, 95% CI 2.7–6.6). This difference may have been due to maternal characteristics such as older age or more advanced disease among women using ddI. No specific pattern of defects was noted and clinical relevance is uncertain. Lactic acidosis, sometimes fatal, has been reported in pregnant women receiving ddI and d4T together.[40, 41] |
| **Stavudine** (d4T) Zerit | Zerit 15-, 20-, 30-, 40-mg capsules or 1-mg/mL oral solution | **Body weight ≥60 kg:** 40 mg BID<br>**Body weight <60 kg:** 30 mg BID<br>Take without regard to meals.<br>WHO recommends 30-mg BID dosing regardless of body weight. | Because of potential toxicities, d4T should be used only in special circumstances where preferred or alternative NRTIs cannot be used. d4T should not be used with ddI or ZDV. | PKs not significantly altered in pregnancy; no change in dose indicated.[9] High placental transfer. | No evidence of human teratogenicity (can rule out 2-fold increase in overall birth defects).[25] Lactic acidosis, sometimes fatal, has been reported in pregnant women receiving ddI and d4T together.[40, 41] |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 5 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **NNRTIs** | | | NNRTIs are recommended for use in combination regimens with 2 NRTI drugs. | | Hypersensitivity reactions, including hepatic toxicity, and rash more common in women; unclear if increased in pregnancy. |
| **Preferred Agents** | | | | | |
| **Nevirapine** (NVP) Viramune | 200-mg tablets or 50-mg/5-mL oral suspension | 200 mg once daily for 14 days (lead-in period); thereafter, 200 mg BID<br>Take without regard to meals.<br>Repeat lead-in period if therapy is discontinued for >7 days.<br>In patients who develop mild-to-moderate rash without constitutional symptoms during lead-in, continue lead-in dosing until rash resolves, but ≤28 days total. | NVP should be initiated in pregnant women with CD4 T-lymphocyte (CD4-cell) counts >250 cells/mm$^3$ only if benefit clearly outweighs risk because of the increased risk of potentially life-threatening hepatotoxicity in women with high CD4-cell counts. Elevated transaminase levels at baseline also may increase the risk of NVP toxicity. Women who become pregnant while taking NVP-containing regimens and are tolerating them well can continue therapy, regardless of CD4-cell count. | PK not significantly altered in pregnancy; no change in dose indicated.[42-44] High placental transfer to fetus. | No evidence of human teratogenicity (can rule out 2-fold increase in overall birth defects).[25] Increased risk of symptomatic, often rash-associated, and potentially fatal liver toxicity among women with CD4-cell counts >250/mm$^3$ when first initiating therapy; [45, 46] unclear if pregnancy increases risk. |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 6 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Use in Special Circumstances** | | | | | |
| **Efavirenz**[d] (EFV) Sustiva | 50-, 200-mg capsules or 600-mg tablets | 600 mg once daily at or before bedtime<br>Take on an empty stomach to reduce side effects. | Non-pregnant women of childbearing potential should undergo pregnancy testing before initiation of EFV and counseling about the potential risk to the fetus and desirability of avoiding pregnancy while on EFV-containing regimens. Alternate ARV regimens that do not include EFV should be strongly considered in women who 1) are planning to become pregnant or 2) are sexually active and not using effective contraception, assuming these alternative regimens are acceptable to the provider and are not thought to compromise the health of the woman. Because the risk of neural tube defects is restricted to the first 5–6 weeks of pregnancy and pregnancy is rarely recognized before 4–6 weeks of pregnancy, and unnecessary ARV drug changes during pregnancy may be associated with loss of viral control and increased risk of perinatal transmission, EFV may be continued in pregnant women receiving an EFV-based regimen who present for antenatal care in the first trimester, provided there is virologic suppression on the regimen (see HIV-Infected Pregnant Women Who are Currently Receiving Antiretroviral Treatment). | AUC decreased during third trimester, compared with postpartum, but nearly all third-trimester subjects exceeded target exposure and no change in dose is indicated.[47] Moderate placental transfer to fetus. | FDA Pregnancy Class D; significant malformations (anencephaly, anophthalmia, cleft palate) were observed in 3 of 20 infants (15%) born to cynomolgus monkeys receiving EFV during the first trimester at a dose resulting in plasma levels comparable to systemic human therapeutic exposure. There are 4 retrospective case reports and 1 prospective case report of neural tube defects in humans with first-trimester exposure and 1 prospective case of anophthalmia with facial clefts; [25, 48, 49] relative risk unclear. |
| | Atripla<br>EFV[d] 600 mg<br>+ FTC 200 mg<br>+ TDF 300 mg | Atripla<br>1 tablet once daily at or before bedtime | | | |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 7 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Insufficient Data to Recommend Use** | | | | | |
| **Etravirine**<br>(ETR)<br>Intelence | 100-, 200-mg tablets | 200 mg BID<br>Take following a meal. | Safety and PK data in pregnancy are insufficient to recommend use during pregnancy. | Limited PK data in pregnancy; in 4 pregnant women, drug levels and AUC similar to those in non-pregnant adults, suggesting no dose modification needed.[50] | Limited experience in human pregnancy. Only 23 first-trimester exposures have been reported to APR. No evidence of teratogenicity in rats and rabbits. |
| **Rilpivirine**<br>(RPV)<br>Endurant | 25-mg tablets | 25 mg once daily with a meal. | Safety and PK data in pregnancy are insufficient to recommend use during pregnancy. | No PK studies in human pregnancy, placental transfer rate unknown. | No published experience in human pregnancy. No evidence of teratogenicity in rats or rabbits. |
| | Complera<br>RPV 25 mg +<br>TDF 300 mg +<br>FTC 200 mg | Complera<br>1 tablet once daily | | | |
| **PIs** | | | PIs are recommended for use in combination regimens with 2 NRTI drugs. | | Hyperglycemia, new onset or exacerbation of diabetes mellitus, and diabetic ketoacidosis reported with PI use; unclear if pregnancy increases risk. Conflicting data regarding preterm delivery in women receiving PIs (see text). |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 8 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Preferred Agents** | | | | | |
| **Atazanavir** (ATV) Reyataz (combined with low-dose RTV boosting) | 100-, 150-, 200-, 300-mg capsules | ATV 300 mg + RTV 100 mg once daily<br><br>Second and third trimester: Some experts recommend increased dose (ATV 400 mg + RTV 100 mg once daily) in all pregnant women in the second and third trimesters<br><br>ATV package insert recommends increased dose (ATV 400 mg + RTV 100 mg once daily) in the following situations:<br>- With TDF or $H_2$-receptor antagonist (not both; use of both with ATV not recommended) in ARV-experienced pregnant patients<br>- With EFV[d] in ARV-naive patients (Concurrent use of ATV with EFV in ARV-experienced patients is not recommended because of decreased ATV levels.)<br><br>Take with food. | Preferred PI for use in combination regimens in pregnancy. Should give as low-dose RTV-boosted regimen, may use once-daily dosing. Several studies have shown decreased ATV plasma concentrations with standard dosing during pregnancy.[32, 51, 52] Use of an increased dose during the second and third trimesters resulted in plasma concentrations equivalent to those in non-pregnant adults on standard dosing.[53] Although some experts recommend increased ATV dosing in all women during the second and third trimesters, the package insert recommends increased ATV dosing only for ARV-experienced pregnant women in the second and third trimesters also receiving either TDF or an $H_2$-receptor antagonist or ARV-naive pregnant women receiving EFV. ATV should not be used in patients receiving both TDF and $H_2$ receptor antagonists or in ARV-experienced patients also taking EFV. | Two of three intensive PK studies of ATV with RTV boosting during pregnancy and the PK study described in the recently approved product label suggest that standard dosing in pregnancy results in decreased plasma concentrations, compared with non-pregnant adults.[32, 35, 51, 52] ATV concentrations further reduced ~25% with concomitant TDF use.[32, 35] Low placental transfer to fetus.[32, 51] | No evidence of human teratogenicity (can rule out 2-fold increase in overall birth defects).[25] Theoretical concern regarding increased indirect bilirubin levels causing significant exacerbation in physiologic hyperbilirubinemia in neonates has not been observed in clinical trials to date.[32, 35, 51, 52, 54] |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 9 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Preferred Agents, continued** | | | | | |
| **Lopinavir + Ritonavir** (LPV/r) Kaletra | Tablets: (LPV 200 mg + RTV 50 mg) or (LPV 100 mg + RTV 25 mg)<br><br>Oral solution: Each 5 mL contains LPV 400 mg + RTV 100 mg<br><br>Oral solution contains 42% alcohol and therefore may not be optimal for use in pregnancy. | LPV/r 400 mg/100 mg BID<br><br>Second and third trimester: Some experts recommend increased dose (LPV/r 600 mg/150 mg BID) in second and third trimesters.<br><br>With EFV[d] or NVP (PI-naive or PI-experienced patients):<br><br>LPV/r 500 mg/125 mg tablets BID (Use a combination of two LPV/r 200 mg/50 mg tablets + one LPV/r 100 mg/25 mg tablet to make a total dose of LPV/r 500 mg/125 mg)<br><br>or<br><br>LPV/r 533 mg/133 mg oral solution (6.5mL) BID.<br><br>Tablets:<br>Take without regard to meals.<br><br>Oral solution:<br>Take with food.<br><br>Not used in pregnancy: Adult dosage of LPV/r 800 mg/200 mg once daily is not recommended for use in pregnancy. | PK studies suggest dose should be increased to 600 mg/150 mg BID in second and third trimesters, especially in PI-experienced patients. If standard dosing is used, monitor virologic response and LPV drug levels, if available. Once-daily LPV/r dosing is not recommended during pregnancy because there are no data to address whether drug levels are adequate with such administration. | AUC decreased in second and third trimesters with standard dosing.[55-57] AUC with dose of LPV/r 600 mg/150 mg twice daily in third trimester in U.S. women resulted in AUC similar to that in non-pregnant adults taking LPV/r 400 mg/100 mg dose twice daily.[30] Low placental transfer to fetus. | No evidence of human teratogenicity (can rule out 2-fold increase in overall birth defects).[25] Well tolerated; short-term safety demonstrated in Phase I/II studies. |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 10 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Preferred Agents, continued** | | | | | |
| **Ritonavir** (RTV) Norvir<br><br>When used as low-dose booster with other PIs | 100-mg capsules<br><br>100-mg tablets<br><br>80-mg/mL oral solution<br><br>Oral solution contains 43% alcohol and therefore may not be optimal for use in pregnancy. | As PK booster for other PIs: 100–400 mg per day in 1–2 divided doses (Refer to other PIs for specific dosing recommendations.)<br><br>Tablets: Take with food.<br><br>Capsule and oral solution: Take with food if possible, which may improve tolerability. | Should only be used in combination with second PI as low-dose RTV "boost" to increase levels of second PI because of low drug levels in pregnant women when used as a sole PI and poor tolerance when given as full dose. | Phase I/II study in pregnancy showed lower levels during pregnancy compared with postpartum.[58] Minimal placental transfer to fetus. | No evidence of human teratogenicity (can rule out 2-fold increase in overall birth defects).[25] Limited experience at full dose in human pregnancy; should be used as low-dose RTV boosting with other PIs. |
| **Alternative Agents** | | | | | |
| **Darunavir** (DRV) Prezista (must be combined with low-dose RTV boosting) | 75-, 150-, 400-, 600-mg tablets | ARV-naive patients: (DRV 800 mg + RTV 100 mg) once daily<br><br>ARV-experienced patients: (DRV 800 mg + RTV 100 mg) once daily if no DRV resistance mutations<br><br>(DRV 600 mg + RTV 100 mg) BID if any DRV resistance mutations<br><br>Some experts recommend use of only twice-daily dosing (DRV 600 mg + RTV 100 mg BID) during pregnancy.<br><br>Unboosted DRV is **not** recommended.<br><br>Take with food. | Safety and PK data in pregnancy are limited. DRV may be considered when preferred and alternative agents cannot be used. Must give as low-dose RTV-boosted regimen. | In PK study of women in the third trimester and postpartum, third-trimester DRV average plasma concentrations were decreased by 23%–28% with once- and twice-daily dosing and third-trimester DRV trough concentrations were low, especially with once-daily dosing.[59] Some experts recommend use of only twice-daily dosing during pregnancy and investigation of use of an increased twice-daily dose is under way. Low placental transfer to fetus.[59] | Insufficient data to assess for teratogenicity in humans. No evidence of teratogenicity in mice, rats, or rabbits but low bioavailability limited exposure. Limited experience in human pregnancy. |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 11 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Alternative Agents, continued** | | | | | |
| **Saquinavir** (SQV) Invirase (available as capsules and tablets. SQV must be combined with low-dose RTV boosting.) | 500-mg tablets or 200-mg capsules | (SQV 1000 mg + RTV 100 mg) BID<br>Unboosted SQV is **not** recommended.<br>Take with meals or within 2 hours after a meal. | PK data on SQV capsules and the tablet formulation in pregnancy are limited. RTV-boosted SQV capsules or SQV tablets are alternative PIs for combination regimens in pregnancy and are alternative initial ARV recommendations for non-pregnant adults. Must give as low-dose RTV-boosted regimen. | Limited PK data on capsules and the 500-mg tablet formulation suggest that 1000-mg SQV capsules /100 mg RTV given twice daily achieves adequate SQV drug levels in pregnant women.[60] Minimal placental transfer to fetus. | Insufficient data to assess for teratogenicity in humans. No evidence of teratogenicity in rats or rabbits but low bioavailability limited exposure. Well tolerated; short-term safety demonstrated for mothers and infants for SQV in combination with low-dose RTV. Baseline ECG recommended before starting because PR and/or QT interval prolongations have been observed and drug is contraindicated in patients with pre-existing cardiac conduction system disease. |
| **Use in Special Circumstances** | | | | | |
| **Indinavir** (IDV) Crixivan (combined with low-dose RTV boosting) | 100-, 200-, 400-mg capsules | With RTV:<br>(IDV 800 mg + RTV 100–200 mg) BID<br>Take without regard to meals.<br>Not used in pregnancy: Adult dosage of IDV (without RTV) 800 mg every 8 hours is not recommended for use in pregnancy. | Because of twice-daily dosing, pill burden, and potential for renal stones, IDV should only be used when preferred and alternative agents cannot be used. Must give as low-dose RTV-boosted regimen. | Two studies including 18 women receiving IDV 800 mg TID showed markedly lower levels during pregnancy compared with postpartum, although suppression of HIV RNA levels was seen.[61, 62] In a study of RTV-boosted IDV (400 mg IDV/100 mg RTV twice daily), 82% of women met the target trough level.[63] Minimal placental transfer to fetus. | No evidence of human teratogenicity (can rule out 2-fold increase in overall birth defects).[25] Theoretical concern regarding increased indirect bilirubin levels, which may exacerbate physiologic hyperbilirubinemia in neonates, but minimal placental passage. Use of unboosted IDV during pregnancy is not recommended. |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 12 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Use in Special Circumstances, continued** | | | | | |
| **Nelfinavir** (NFV) Viracept | 250-, 625-mg tablets<br>50-mg/g oral powder | 1250 mg BID<br>Take with food.<br>Not used in pregnancy: Adult dosage of NFV 750 mg TID is not recommended for use in pregnancy. | Given PK data and extensive experience with use in pregnancy, NFV might be considered in special circumstances for prophylaxis of transmission in women in whom therapy would not otherwise be indicated when alternative agents are not tolerated. In clinical trials of initial therapy in non-pregnant adults, NFV-based regimens had a lower rate of viral response compared with LPV/r- or EFV-based regimens but similar viral response to ATV- or NVP-based regimens. | Adequate drug levels are achieved in pregnant women with NFV 1250 mg given twice daily, although levels are variable in late pregnancy.[43, 64, 65] In a study of women in their second and third trimesters dosed at 1250 mg twice daily, women in the third trimester had lower concentration of NFV than those in the second trimester.[65] In a study of the new 625-mg tablet formulation dosed at 1250 mg twice daily, lower AUC and peak levels were observed during the third trimester than postpartum.[66] Minimal to low placental transfer to fetus. | No evidence of human teratogenicity (can rule out 2-fold increase in overall birth defects).[25] Well tolerated; short-term safety demonstrated for mothers and infants. |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 13 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Insufficient Data to Recommend Use** | | | | | |
| **Fosamprenavir** (FPV) Lexiva (a prodrug of amprenavir) (recommended to be combined with low-dose RTV boosting) | 700-mg tablet or 50-mg/mL oral suspension | ARV-naive patients:<br>• FPV 1400 mg BID or<br>• (FPV 1400 mg + RTV 100–200 mg) once daily or<br>• (FPV 700 mg + RTV 100 mg) BID<br><br>PI-experienced patients (once-daily dosing **not** recommended):<br>• (FPV 700 mg + RTV 100 mg) BID<br><br>With EFV:<br>• (FPV 700 mg + RTV 100 mg) BID or<br>• (FPV 1400 mg + RTV 300 mg) once daily<br><br>Tablet:<br>Take without regard to meals (if not boosted with RTV tablet).<br><br>Suspension:<br>Take without food.<br><br>FPV with RTV tablet:<br>Take with meals. | Safety and PK data in pregnancy are insufficient to recommend routine use during pregnancy in ARV-naive patients. Recommended to be given as low-dose RTV-boosted regimen. | With RTV boosting, AUC is reduced during the third trimester. However, exposure is greater during the third trimester with boosting than in non-pregnant adults without boosting and trough concentrations achieved during the third trimester were adequate for patients without PI resistance mutations.[67] Low placental transfer to fetus. | Insufficient data to assess for teratogenicity in humans. Increased fetal loss in rabbits but no increase in defects in rats and rabbits. Limited experience in human pregnancy. |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 14 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Insufficient Data to Recommend Use, continued** | | | | | |
| **Tipranavir** (TPV) Aptivus (must be combined with low-dose RTV boosting) | 250-mg capsules or 100-mg/mL oral solution | (TPV 500 mg + RTV 200 mg) BID<br>Unboosted TPV is **not** recommended.<br>TPV taken with RTV tablets: Take with meals.<br>TPV taken with RTV capsules or solution: Take without regard to meals. | Safety and PK data in pregnancy are insufficient to recommend routine use during pregnancy in ARV-naive patients. Must give as low-dose RTV-boosted regimen. | Limited PK studies in human pregnancy. Moderate placental transfer to fetus reported in one patient.[68] | Insufficient data to assess for teratogenicity in humans. No teratogenicity in rats or rabbits. Limited experience in human pregnancy. |
| **Entry Inhibitors** | | | | | |
| **Insufficient Data to Recommend Use** | | | | | |
| **Enfuvirtide** (T20) Fuzeon | • Injectable—supplied as lyophilized powder<br>• Each vial contains 108 mg of T20; reconstitute with 1.1 mL of sterile water for injection for delivery of approximately 90 mg/1 mL. | 90 mg (1mL) SQ BID | Safety and PK data in pregnancy are insufficient to recommend use during pregnancy in ARV-naive patients. | Limited PK studies in human pregnancy. No placental transfer to fetus, based on very limited data.[68,69] | Insufficient data to assess for teratogenicity in humans. No evidence of teratogenicity in rats or rabbits. Minimal data in human pregnancy.[68, 70] |

**Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 15 of 16)**

| ARV Drug Generic Name (Abbreviation) Trade Name | Formulation | Dosing Recommendations[a] | Recommendations for Use in Pregnancy | PKs in Pregnancy[b] | Concerns in Pregnancy |
|---|---|---|---|---|---|
| **Entry Inhibitors, continued** | | | | | |
| **Insufficient Data to Recommend Use, continued** | | | | | |
| **Maraviroc** (MVC) Selzentry | 150-, 300-mg tablets | • **150 mg BID** when given with strong CYP3A inhibitors (with or without CYP3A inducers) including PIs (except TPV/r)<br>• **300 mg BID** when given with NRTIs, NVP, RAL, T-20, TPV/r, and other drugs that are not strong CYP3A inhibitors or inducers<br>• **600 mg BID** when given with CYP3A inducers, including EFV, ETR (without a CYP3A inhibitor)<br>Take without regard to meals. | Safety and PK data in pregnancy are insufficient to recommend use during pregnancy in ARV-naive patients. | No PK studies in human pregnancy. Unknown placental transfer rate to fetus. | Insufficient data to assess for teratogenicity in humans. No evidence of teratogenicity in rats or rabbits. Limited experience in human pregnancy. |
| **Integrase Inhibitors** | | | | | |
| **Use in Special Circumstances** | | | | | |
| **Raltegravir** (RAL) Isentress | 400-mg tablets | 400 mg BID<br>With rifampin:<br>800 mg BID<br>Take without regard to meals. | Safety and PK data in pregnancy are limited; can be considered for use in special circumstances when preferred and alternative agents cannot be used. | During third trimester, RAL PK showed extensive variability but RAL exposure was not consistently altered compared with postpartum and historical data. The standard dose appears appropriate during pregnancy.[71] Variable but high placental transfer to fetus.[71, 72] | Insufficient data to assess for teratogenicity in humans. Increased skeletal variants in rats, no increase in defects in rabbits. Limited experience in human pregnancy. |

## Table 5. Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy (page 16 of 16)

**Key to Abbreviations:** APR = Antiretroviral Pregnancy Registry, ARV = antiretroviral, AUC = area under the curve, BID = twice daily, CI = confidence interval, CYP = cytochrome P, EC = enteric coated, ECG = electrocardiogram, FDA = Food and Drug Administration, HBV = hepatitis B virus, IV = intravenous, NNRTI = non-nucleoside reverse transcriptase inhibitor, NRTI = nucleoside/nucleotide reverse transcriptase inhibitor, PI = protease inhibitor, PK = pharmacokinetic, PPI = proton pump inhibitor, SQ = subcutaneous injection, TID = three times daily, WHO = World Health Organization

[a] Dosage should be adjusted in renal or hepatic insufficiency (see *Adult Guidelines, Appendix B, Table 7*).

[b] Placental transfer categories—Mean or median cord blood/maternal delivery plasma drug ratio:

High: >0.6
Moderate: 0.3–0.6
Low: 0.1–0.3
Minimal: <0.1

[c] Triple-NRTI regimens including abacavir have been less potent virologically compared with PI-based combination ARV drug regimens. Triple-NRTI regimens should be used only when an NNRTI- or PI-based combination regimen cannot be used, such as because of significant drug interactions.

[d] See Teratogenicity for discussion of efavirenz and risks in pregnancy.

## *Recommendations for Use of Antiretroviral Drugs during Pregnancy*

The Panel recommends that choice of ARV drug regimens for HIV-infected pregnant women be based on the same principles used to choose regimens for non-pregnant individuals, unless there are compelling pregnancy-specific maternal or fetal safety issues associated with specific drugs. The Panel reviews clinical trial data published in peer-reviewed journals and data prepared by manufacturers for Food and Drug Administration review related to treatment of HIV-infected adult women, both pregnant and non-pregnant. The durability, tolerability, and simplicity of a medication regimen is particularly important for preserving future options for women who decide to stop medications after delivery and those who meet standard criteria for initiation of ART per adult guidelines and will continue their regimens after pregnancy. Regimen selection should be individualized and the following factors should be considered:

- comorbidities,
- patient adherence potential,
- convenience,
- potential adverse maternal drug effects,
- potential drug interactions with other medications,
- results of genotypic resistance testing,
- pharmacokinetic (PK) changes in pregnancy,
- potential teratogenic effects and other adverse effects on fetuses or newborns, and
- experience with use in pregnancy.

Information used by the Panel for recommendations on specific drugs or regimens for pregnant women include:

- Data from randomized, prospective clinical trials that demonstrate durable viral suppression as well as immunologic and clinical improvement;
- Incidence rates and descriptions of short- and long-term drug toxicity of ARV regimens, with special attention to maternal toxicity and potential teratogenicity and fetal safety;
- Specific knowledge about drug tolerability and simplified dosing regimens;
- Known efficacy of ARV drug regimens in reducing mother-to-child transmission of HIV;
- PK data during the prenatal period. (The physiologic changes of pregnancy have the potential to alter drug PK. ARV dosing during pregnancy should be based on PK data from studies in pregnant women. Physiologic changes are not fixed throughout pregnancy but, rather, reflect a continuum of change as pregnancy progresses, with return to baseline at various rates in the postpartum period.); and
- Data from animal teratogenicity studies.

Categories of ARV regimens include:

- ***Preferred:*** Drugs or drug combinations are designated as preferred for use in pregnant women when clinical trial data in adults have demonstrated optimal efficacy and durability with acceptable toxicity and ease of use; pregnancy-specific PK data are available to guide dosing; and no evidence of teratogenic effects or established association with teratogenic or clinically significant adverse outcomes for mothers, fetuses, or newborn are present.
- ***Alternative:*** Drugs or drug combinations are designated as alternatives for initial therapy in pregnant women when clinical trial data in adults show efficacy but any one or more of the following conditions apply: Experience in pregnancy is limited; data are lacking on teratogenic effects on the

fetus; or the drug or regimen is associated with dosing, formulation, administration, or interaction issues.

- ***Use in Special Circumstances:*** Drug or drug combinations in this category can be considered for use when intolerance or resistance prohibits use of other drugs with fewer toxicity concerns or in women who have comorbidities or require concomitant medications that may limit drug choice, such as active tuberculosis requiring rifampin therapy.
- ***Not Recommended:*** Drugs and drug combinations listed in this category are not recommended for therapy in pregnant women because of inferior virologic response, potentially serious maternal or fetal safety concerns, or pharmacologic antagonism.
- ***Insufficient Data to Recommend:*** The drugs and drug combinations in this category are approved for use in adults but lack pregnancy-specific PK or safety data or such data are too limited to make a recommendation for use in pregnancy.

In pregnancy, a combination ARV regimen with at least three agents is recommended for either treatment or prophylaxis. Recommendations for choice of ARV drug regimen during pregnancy must be individualized according to a pregnant woman's specific ARV history and the presence of comorbidities. Some women may become pregnant and present for obstetrical care while receiving ART for their own health. In these cases, the choice of active drugs with known safety data in pregnancy may be more limited. In general, women who are already on a fully suppressive regimen should continue their regimens (see HIV-Infected Pregnant Women Who Are Currently Receiving Antiretroviral Therapy).

Other HIV-infected women may not be receiving ART at the time they present for obstetrical care. Some women have never received ARV drugs, and others may have taken ARV drugs for treatment that was stopped, for prophylaxis to prevent perinatal transmission of HIV in prior pregnancies, or for pre- or post-exposure prophylaxis. The following sections provide detailed discussions of recommendations based on maternal ARV history and whether there are maternal indications for therapy.

For ARV-naive women, a combination regimen including two NRTIs and either an NNRTI or a PI (generally with low-dose ritonavir) would be preferred.

The preferred NRTI combination for ARV-naive pregnant women is zidovudine/lamivudine, based on efficacy studies in preventing perinatal transmission (see Lessons from Clinical Trials of Antiretroviral Interventions to Reduce Perinatal HIV Transmission) and extensive experience with safe use in pregnancy. Alternate regimens can be used in women who are intolerant of zidovudine because of toxicity such as severe anemia or who have known resistance to the drug.

Tenofovir is a preferred NRTI for non-pregnant women. Data from the Antiretroviral Pregnancy Registry on 1,219 pregnancies with first-trimester exposure to the drug have shown no increase in overall birth defects compared with the general population.[25] Animal studies, however, have shown decreased fetal growth and reduction in fetal bone porosity, and some studies in infected children on chronic tenofovir-based therapy have shown bone demineralization in some children. Therefore, tenofovir would be considered an alternative NRTI during pregnancy for ARV-naive women. For pregnant women with chronic HBV infection, however, tenofovir in combination with emtricitabine or lamivudine would be the preferred NRTI backbone in a combination ARV regimen. The combination of stavudine/didanosine should not be used in pregnant women because fatal cases of lactic acidosis and hepatic failure have been reported in women who received this combination throughout pregnancy.

In addition to the two NRTIs, either an NNRTI or a PI would be preferred for combination regimens in ARV-naive pregnant women. Efavirenz, the preferred NNRTI for non-pregnant adults, is not recommended for initiation in ARV-naive women in the first trimester because of concerns related to teratogenicity (see

Teratogenicity). Non-pregnant women of childbearing potential should undergo pregnancy testing before initiation of EFV and counseling about the potential risk to the fetus and desirability of avoiding pregnancy while on EFV-containing regimens. Alternate ARV regimens that do not include EFV should be strongly considered in women who 1) are planning to become pregnant or 2) are sexually active and not using effective contraception, assuming these alternative regimens are acceptable to the provider and are not thought to compromise the health of the woman. Because the risk of neural tube defects is restricted to the first 5–6 weeks of pregnancy and pregnancy is rarely recognized before 4–6 weeks of pregnancy, and unnecessary ARV drug changes during pregnancy may be associated with loss of viral control and increased risk of perinatal transmission, EFV may be continued in pregnant women receiving an EFV-based regimen who present for antenatal care in the first trimester, provided there is virologic suppression on the regimen (see HIV-Infected Pregnant Women Who are Currently Receiving Antiretroviral Treatment). Initiation of efavirenz can be considered after the first trimester, based on clinical indication, but current data are limited in defining the safety of this use. Nevirapine would be the preferred NNRTI for ARV-naive pregnant women with CD4-cell counts <250 cells/mm$^3$, and it can be continued in ARV-experienced women already receiving a nevirapine-based regimen, regardless of CD4-cell count. In general, nevirapine should not be initiated in treatment-naive women with CD4-cell counts >250 cells/mm$^3$ because of an increased risk of symptomatic and potentially fatal rash and hepatic toxicity (see Special Considerations Regarding the Use of Antiretroviral Drugs by HIV-Infected Pregnant Women and their Infants). Elevated transaminase levels at baseline also may increase the risk of nevirapine toxicity.[73] Safety and PK data on etravirine and rilpivirine in pregnancy are insufficient to recommend use of these NNRTI drugs in ARV-naive women.

Lopinavir/ritonavir and atazanavir with low-dose ritonavir boosting are the preferred PI drugs for use in ARV-naive pregnant women, based on efficacy studies in adults and experience with use in pregnancy (see Table 5 for dosing considerations). Alternative PIs include ritonavir-boosted saquinavir or darunavir, although experience is more limited with these regimens in pregnancy.[59, 74, 75] Nelfinavir can be considered in special circumstances when used solely for prophylaxis of perinatal transmission in ARV-naive women for whom therapy would not otherwise be indicated and who cannot tolerate alternative agents. PK data and extensive clinical experience do exist for nelfinavir in pregnancy, but the rate of viral response to nelfinavir-based regimens was lower than lopinavir/ritonavir or efavirenz-based regimens in clinical trials of initial therapy in non-pregnant adults. Indinavir also can be considered in special circumstances for women in whom preferred or alternative drugs cannot be used. Indinavir may be associated with renal stones and has a higher pill burden than many other PI drugs. Data on use in pregnancy are too limited to recommend routine use of fosamprenavir and tipranavir in pregnant women, although they can be considered for women who are intolerant of other agents.

Safety and PK data in pregnancy are insufficient to recommend use of the entry inhibitors enfuvirtide and maraviroc in ARV-naive women during pregnancy. Use of these agents can be considered for women who have failed therapy with several other classes of ARV drugs after consultation with HIV and obstetric specialists.

Data on the integrase inhibitor raltegravir during pregnancy are limited but increasing; ART regimens including raltegravir can be considered for use in pregnancy in special circumstances when preferred and alternative agents cannot be used.[71, 72, 74, 76, 77]

Although data are insufficient to support or refute the teratogenic risk of ARV drugs when administered during the first trimester, information to date does not support major teratogenic effects for the majority of such agents. (For further data, see www.APRegistry.com.) However, certain drugs are of more concern than others—for example, efavirenz should be avoided during the first trimester when possible (see Supplement: Safety and Toxicity of Individual Antiretroviral Drugs in Pregnancy).

Table 5 provides recommendations for use of specific ARV drugs in pregnancy and data on PK and toxicity in pregnancy. Table 6 summarizes management recommendations for the mothers and infants in a variety of clinical scenarios.

**Table 6. Clinical Scenario Summary Recommendations for Antiretroviral Drug Use by Pregnant HIV-Infected Women and Prevention of Perinatal Transmission of HIV-1 in the United States (page 1 of 4)**

| Clinical Scenario | Recommendations |
|---|---|
| **Non-pregnant HIV-infected women of childbearing potential (sexually active and not using contraception) who have indications for initiating antiretroviral therapy (ART)** | Initiate combination antiretroviral (ARV) drug therapy as per adult treatment guidelines. When feasible, include one or more nucleoside reverse transcriptase inhibitors (NRTIs) with good placental passage as a component of the ARV regimen.<br>• Exclude pregnancy and ensure access to effective contraception for sexually active women before starting treatment with efavirenz; alternative ART regimens that do not include efavirenz should be strongly considered in women who are planning to become pregnant. Emphasize need for women on efavirenz to review their regimens with their providers before discontinuing contraception. |
| **HIV-infected women on ART who become pregnant** | **Women:**<br>• In general, in women who require treatment, ARV drugs should not be stopped during the first trimester or during pregnancy.<br>• Continue current combination ARV regimen, assuming the regimen is tolerated and effective in successfully suppressing viremia.<br>• Perform HIV ARV drug-resistance testing in women on therapy who have detectable viremia (that is, >500–1,000 copies/mL).<br>• Continue the ART regimen during the intrapartum period (if oral zidovudine is part of the antepartum regimen, and a woman's viral load is >400 copies/mL, the oral zidovudine component of her regimen should be stopped while she receives zidovudine as an intravenous continuous infusion[a] during labor and other ARV agents are continued orally) and postpartum.<br>• Schedule cesarean delivery at 38 weeks if plasma HIV RNA remains >1,000 copies/mL near the time of delivery.<br>**Infants:**<br>• Start zidovudine as soon as possible after birth and administer for 6 weeks.[b] |

**Table 6. Clinical Scenario Summary Recommendations for Antiretroviral Drug Use by Pregnant HIV-Infected Women and Prevention of Perinatal Transmission of HIV-1 in the United States (page 2 of 4)**

| Clinical Scenario | Recommendations |
|---|---|
| **HIV-infected pregnant women who are ARV naive** | **Women:** Perform HIV ARV drug-resistance testing before initiating combination ARV drug therapy and repeat after initiating therapy if viral suppression is suboptimal (<1 log drop after 4 weeks on ARVs). If HIV is diagnosed late in pregnancy, the ARV regimen should be initiated promptly without waiting for the results of resistance testing.<br><br>• Initiate combination ARV regimen.<br><br>- Delayed initiation of ARVs until after the first trimester can be considered in women with high CD4 T-lymphocyte (CD4-cell) counts and low HIV RNA levels, but earlier initiation may be more effective in reducing perinatal transmission of HIV. Benefits of first trimester use must be weighed against potential fetal effects of first-trimester exposure.<br><br>- Avoid initiation of efavirenz or other potentially teratogenic drugs in the first trimester and drugs with known adverse potential for mother throughout the pregnancy.<br><br>- When feasible, include one or more NRTIs with good placental passage (zidovudine, lamivudine, emtricitabine, tenofovir, or abacavir) in the ARV regimen.<br><br>- Use nevirapine as a component of the ARV regimen only in women who have CD4-cell counts ≤250 cells/mm$^3$. Because of the increased risk of severe hepatic toxicity, use nevirapine in women with CD4-cell counts >250 cells/mm$^3$ only if the benefit clearly outweighs the risk.<br><br>• Continue the combination regimen intrapartum. Continuous infusion zidovudine[a] should be administered to HIV-infected women with HIV RNA >400 copies/mL (or unknown HIV RNA) near delivery, regardless of antepartum regimen or mode of delivery. If oral zidovudine is part of the antepartum regimen, and a woman's viral load is >400 copies/mL, the oral zidovudine component of her regimen should be stopped while she receives zidovudine as an intravenous continuous infusion[a] during labor while other ARV agents are continued orally and postpartum.<br><br>• Schedule cesarean delivery at 38 weeks if plasma HIV RNA remains >1,000 copies/mL near the time of delivery.<br><br>• Evaluate need for continuing the combination regimen postpartum. Following delivery, considerations for continuation of the mother's ARV regimen are the same as in other non-pregnant individuals (see General Principles Regarding Use of Antiretroviral Drugs in Pregnancy). If treatment is to be stopped and the regimen includes a drug with a long half-life, such as a non-nucleoside reverse transcriptase inhibitor [NNRTI]), continue NRTIs for at least 7 days after stopping NNRTI (see Stopping Antiretroviral Therapy and Prevention of Antiretroviral Drug Resistance).<br><br>**Infants:**<br><br>• Start zidovudine as soon as possible after birth and administer for 6 weeks.[b] |

**Table 6. Clinical Scenario Summary Recommendations for Antiretroviral Drug Use by Pregnant HIV-Infected Women and Prevention of Perinatal Transmission of HIV-1 in the United States (page 3 of 4)**

| Clinical Scenario | Recommendations |
|---|---|
| **HIV-infected pregnant women who are ARV experienced but not currently receiving ARV drugs** | **Women:**<br>• Obtain full ARV drug history, including prior resistance testing, and evaluate need for ART for maternal health.<br>• Test for HIV ARV drug resistance before reinitiating ARV prophylaxis or therapy and retest after initiating combination ARV regimen if viral suppression is suboptimal (<1 log drop after 4 weeks on ARVs). If HIV is diagnosed late in pregnancy, the ARV regimen should be initiated promptly without waiting for the results of resistance testing.<br>• Initiate a combination ARV regimen (that is, at least three drugs), with the regimen chosen based on results of resistance testing and history of prior therapy.<br>- Delayed initiation of ARVs until after the first trimester can be considered in women with high CD4-cell counts and low HIV RNA levels, but earlier initiation of prophylaxis may be more effective in reducing perinatal transmission of HIV. Benefits of first trimester use must be weighed against potential fetal effects of first-trimester exposure.<br>- Avoid initiation of efavirenz or other potentially teratogenic drugs in the first trimester and drugs with known adverse potential for the mother throughout the pregnancy.<br>- When feasible, include one or more NRTIs with good transplacental passage (zidovudine, lamivudine, emtricitabine, tenofovir, or abacavir) as a component of the ARV regimen.<br>- Use nevirapine as a component of therapy in women who have CD4-cell counts >250 cells/mm$^3$ only if the benefit clearly outweighs the risk because of the drug's association with an increased risk of severe hepatic toxicity.<br>• Continue the combination regimen intrapartum. Continuous infusion zidovudine[a] should be administered to HIV-infected women with HIV RNA >400 copies/mL (or unknown HIV RNA) near delivery, regardless of antepartum regimen or mode of delivery. If oral zidovudine is part of the antepartum regimen, and a woman's viral load is >400 copies/mL, the oral zidovudine component of her regimen should be stopped while she receives zidovudine as an intravenous continuous infusion[a] during labor while other ARV agents are continued orally.<br>• Evaluate need for continuing the combination regimen postpartum. Following delivery, considerations for continuation of the mother's ARV regimen are the same as in other non-pregnant adults (see General Principles Regarding Use of Antiretroviral Drugs in Pregnancy). If treatment is to be stopped and the regimen includes a drug with a long half-life, such as NNRTIs, continue NRTIs for at least 7 days after stopping NNRTIs (see Stopping Antiretroviral Therapy and Prevention of Antiretroviral Drug Resistance).<br>• Schedule cesarean delivery at 38 weeks if plasma HIV RNA remains >1,000 copies/mL near the time of delivery.<br>**Infant:**<br>• Start zidovudine as soon as possible after birth and administer for 6 weeks.[b] |

**Table 6. Clinical Scenario Summary Recommendations for Antiretroviral Drug Use by Pregnant HIV-Infected Women and Prevention of Perinatal Transmission of HIV-1 in the United States (page 4 of 4)**

| Clinical Scenario | Recommendations |
|---|---|
| **HIV-infected women who have received no ARV before labor** | **Women:** Give zidovudine as continuous infusion[a] during labor.<br><br>**Infants:** Infants born to HIV-infected women who have not received antepartum ARV drugs should receive prophylaxis with a combination ARV drug regimen started as close to the time of birth as possible. Zidovudine[b] given for 6 weeks combined with three doses of nevirapine in the first week of life (at birth, 48 hours later, and 96 hours after the second dose) has been shown to be effective in a randomized controlled trial and less toxic than a three-drug regimen with nelfinavir and lamivudine for 2 weeks and 6 weeks of zidovudine. The two-drug regimen is preferred because of lower toxicity and because nelfinavir powder is no longer available in the United States (see Infant Antiretroviral Prophylaxis and Table 9).<br><br>• Evaluate need for initiation of maternal therapy postpartum. |
| **Infants born to HIV-infected women who have received no ARV before or during labor** | • Infants born to HIV-infected women who have not received antepartum ARV drugs should receive prophylaxis with a combination ARV drug regimen started as close to the time of birth as possible. Zidovudine[b] given for 6 weeks combined with three doses of nevirapine in the first week of life (at birth, 48 hours later, and 96 hours after the second dose) has been shown to be effective in a randomized controlled trial and less toxic than a three-drug regimen with nelfinavir and lamivudine for 2 weeks and 6 weeks of zidovudine. The two-drug regimen is preferred because of lower toxicity and because nelfinavir powder is no longer available in the United States (see Infant Antiretroviral Prophylaxis and Table 9).<br><br>• Evaluate need for initiation of maternal therapy postpartum. |

**Key to Abbreviations:** ARV = antiretroviral; ART = antiretroviral therapy; IV = intravenously; NRTI = nucleoside reverse transcriptase inhibitor; NNRTI = non-nucleoside reverse transcriptase inhibitor

[a] Zidovudine continuous infusion: 2 mg/kg zidovudine IV over 1 hour, followed by continuous infusion of 1 mg/kg/hour until delivery.

[b] Zidovudine dosing for infants varies by gestational age – see Table 9.

## References


1. Kaplan JE, Benson C, Holmes KH, et al. Guidelines for prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from CDC, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. *MMWR Recomm Rep*. Apr 10 2009;58(RR-4):1-207; quiz CE201-204. Available at http://www.ncbi.nlm.nih.gov/pubmed/19357635.
2. Centers for Disease Control and Prevention C. Guidelines for vaccinating pregnant women, Available at: http://www.cdc.gov/vaccines/pubs/downloads/b_preg_guide.pdf. 2007; Atlanta, GA.

3. Centers for Disease Control and Prevention. Updated recommendations for use of tetanus toxoid, reduced diphtheria toxoid and acellular pertussis vaccine (Tdap) in pregnant women and persons who have or anticipate having close contact with an infant aged <12 months --- Advisory Committee on Immunization Practices (ACIP), 2011. *MMWR Morb Mortal Wkly Rep*. Oct 21 2011;60(41):1424-1426. Available at http://www.ncbi.nlm.nih.gov/pubmed/22012116.

4. Cooper ER, Charurat M, Mofenson L, et al. Combination antiretroviral strategies for the treatment of pregnant HIV-1-infected women and prevention of perinatal HIV-1 transmission. *J Acquir Immune Defic Syndr*. Apr 15 2002;29(5):484-494. Available at http://www.ncbi.nlm.nih.gov/pubmed/11981365.

5. Cohen MS, Chen YQ, McCauley M, et al. Prevention of HIV-1 infection with early antiretroviral therapy. *N Engl J Med*. Aug 11 2011;365(6):493-505. Available at http://www.ncbi.nlm.nih.gov/pubmed/21767103.

6. Hirt D, Urien S, Rey E, et al. Population pharmacokinetics of emtricitabine in human immunodeficiency virus type 1-infected pregnant women and their neonates. *Antimicrob Agents Chemother*. Mar 2009;53(3):1067-1073. Available at http://www.ncbi.nlm.nih.gov/pubmed/19104016.

7. Hirt D, Urien S, Ekouevi DK, et al. Population pharmacokinetics of tenofovir in HIV-1-infected pregnant women and their neonates (ANRS 12109). *Clin Pharmacol Ther*. Feb 2009;85(2):182-189. Available at http://www.ncbi.nlm.nih.gov/pubmed/18987623.

8. Moodley D, Pillay K, Naidoo K, et al. Pharmacokinetics of zidovudine and lamivudine in neonates following coadministration of oral doses every 12 hours. *J Clin Pharmacol*. Jul 2001;41(7):732-741. Available at http://www.ncbi.nlm.nih.gov/pubmed/11452705.

9. Wade NA, Unadkat JD, Huang S, et al. Pharmacokinetics and safety of stavudine in HIV-infected pregnant women and their infants: Pediatric AIDS Clinical Trials Group protocol 332. *J Infect Dis*. Dec 15 2004;190(12):2167-2174. Available at http://www.ncbi.nlm.nih.gov/pubmed/15551216.

10. Watts DH, Lu M, Thompson B, et al. Treatment interruption after pregnancy: effects on disease progression and laboratory findings. *Infect Dis Obstet Gynecol*. 2009;2009:456717. Available at http://www.ncbi.nlm.nih.gov/pubmed/19893751.

11. Palacios R, Senise J, Vaz M, Diaz R, Castelo A. Short-term antiretroviral therapy to prevent mother-to-child transmission is safe and results in a sustained increase in CD4 T-cell counts in HIV-1-infected mothers. *HIV Med*. Mar 2009;10(3):157-162. Available at http://www.ncbi.nlm.nih.gov/pubmed/19245537.

12. Tai JH, Udoji MA, Barkanic G, et al. Pregnancy and HIV disease progression during the era of highly active antiretroviral therapy. *J Infect Dis*. Oct 1 2007;196(7):1044-1052. Available at http://www.ncbi.nlm.nih.gov/pubmed/17763327.

13. When To Start Consortium, Sterne JA, May M, et al. Timing of initiation of antiretroviral therapy in AIDS-free HIV-1-infected patients: a collaborative analysis of 18 HIV cohort studies. *Lancet*. Apr 18 2009;373(9672):1352-1363. Available at http://www.ncbi.nlm.nih.gov/pubmed/19361855.

14. Kitahata MM, Gange SJ, Abraham AG, et al. Effect of early versus deferred antiretroviral therapy for HIV on survival. *N Engl J Med*. Apr 30 2009;360(18):1815-1826. Available at http://www.ncbi.nlm.nih.gov/pubmed/19339714.

15. Mellins CA, Chu C, Malee K, et al. Adherence to antiretroviral treatment among pregnant and postpartum HIV-infected women. *AIDS Care*. Sep 2008;20(8):958-968. Available at http://www.ncbi.nlm.nih.gov/pubmed/18608073.

16. Fox Z, Phillips A, Cohen C, et al. Viral resuppression and detection of drug resistance following interruption of a suppressive non-nucleoside reverse transcriptase inhibitor-based regimen. *AIDS*. Nov 12 2008;22(17):2279-2289. Available at http://www.ncbi.nlm.nih.gov/pubmed/18981767.

17. Burns DN, Landesman S, Muenz LR, et al. Cigarette smoking, premature rupture of membranes and vertical transmission of HIV-1 among women with low CD4+ levels. *J Acquir Immune Defic Syndr Hum Retrovirol*. 1994;7(7):718-726. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=7911527&dopt=Abstract.

18. Turner BJ, Hauck WW, Fanning TR, Markson LE. Cigarette smoking and maternal-child HIV transmission. *J Acquir Immune Defic Syndr Hum Retrovirol*. Apr 1 1997;14(4):327-337. Available at http://www.ncbi.nlm.nih.gov/pubmed/9111474.

19. Rodriguez EM, Mofenson LM, Chang BH, et al. Association of maternal drug use during pregnancy with maternal HIV culture positivity and perinatal HIV transmission. *AIDS*. 1996;10(3):273-282. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=8882667&dopt=Abstract.

20. Bulterys M, Landesman S, Burns DN, et al. Sexual behavior and injection drug use during pregnancy and vertical transmission of HIV-1. *J Acquir Immune Defic Syndr Human Retrovirol*. 1997;15(1):76-82. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=9215658&dopt=Abstract.

21. Matheson PB, Thomas PA, Abrams EJ, et al. Heterosexual behavior during pregnancy and perinatal transmission of HIV-1. New York City Perinatal HIV Transmission Collaborative Study Group. *AIDS*. Sep 1996;10(11):1249-1256. Available at http://www.ncbi.nlm.nih.gov/pubmed/8883587.

22. Branson BM, Handsfield HH, Lampe MA, et al. Revised recommendations for HIV testing of adults, adolescents, and pregnant women in health-care settings. *MMWR Recomm Rep*. Sep 22 2006;55(RR-14):1-17; quiz CE11-14. Available at http://www.ncbi.nlm.nih.gov/pubmed/16988643.

23. Gaur AH, Freimanis-Hance L, Dominguez K, et al. Knowledge and practice of prechewing/prewarming food by HIV-infected women. *Pediatrics*. May 2011;127(5):e1206-1211. Available at http://www.ncbi.nlm.nih.gov/pubmed/21482608.

24. Moodley J, Moodley D, Pillay K, et al. Pharmacokinetics and antiretroviral activity of lamivudine alone or when coadministered with zidovudine in human immunodeficiency virus type 1-infected pregnant women and their offspring. *J Infect Dis*. Nov 1998;178(5):1327-1333. Available at http://www.ncbi.nlm.nih.gov/pubmed/9780252.

25. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.

26. O'Sullivan MJ, Boyer PJ, Scott GB, et al. The pharmacokinetics and safety of zidovudine in the third trimester of pregnancy for women infected with human immunodeficiency virus and their infants: phase I acquired immunodeficiency syndrome clinical trials group study (protocol 082). Zidovudine Collaborative Working Group. *Am J Obstet Gynecol*. 1993;168(5):1510-1516. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=8098905.

27. Best BM, Mirochnick M, Capparelli EV, et al. Impact of pregnancy on abacavir pharmacokinetics. *AIDS*. Feb 28 2006;20(4):553-560. Available at http://www.ncbi.nlm.nih.gov/pubmed/16470119.

28. Mallal S, Phillips E, Carosi G, et al. HLA-B*5701 screening for hypersensitivity to abacavir. *N Engl J Med*. Feb 7 2008;358(6):568-579. Available at http://www.ncbi.nlm.nih.gov/pubmed/18256392.

29. Saag M, Balu R, Phillips E, et al. High sensitivity of human leukocyte antigen-b*5701 as a marker for immunologically confirmed abacavir hypersensitivity in white and black patients. *Clin Infect Dis*. Apr 1 2008;46(7):1111-1118. Available at http://www.ncbi.nlm.nih.gov/pubmed/18444831.

30. Best BM, Stek AM, Mirochnick M, et al. Lopinavir tablet pharmacokinetics with an increased dose during pregnancy. *J Acquir Immune Defic Syndr*. Aug 2010;54(4):381-388. Available at http://www.ncbi.nlm.nih.gov/pubmed/20632458.

31. Burchett SK, Best B, Mirochnick M, et al. Tenofovir pharmacokinetics during pregnancy, at delivery and postpartum. Paper presented at: 14th Conference on Retroviruses and Opportunistic Infections (CROI); February 25-28, 2007; Los Angeles, CA. Abstract 738b.

32. Mirochnick M, Best BM, Stek AM, et al. Atazanavir pharmacokinetics with and without tenofovir during pregnancy. *J Acquir Immune Defic Syndr*. Apr 15 2011;56(5):412-419. Available at http://www.ncbi.nlm.nih.gov/pubmed/21283017.

33. Mirochnick M, Kunwenda N, Joao E, et al. Tenofovir disoproxil fumarate (TDF) pharmacokinetics (PK) with increased doses in HIV-1 infected pregnant women and their newborns (HPTN 057). Paper presented at: 11th International

Workshop on Clinical Pharmacology of HIV Therapy; April 7-9, 2010; Sorrento, Italy. Abstract 3.

34. Flynn PM, Mirochnick M, Shapiro DE, et al. Pharmacokinetics and safety of single-dose tenofovir disoproxil fumarate and emtricitabine in HIV-1-infected pregnant women and their infants. *Antimicrob Agents Chemother*. Dec 2011;55(12):5914-5922. Available at http://www.ncbi.nlm.nih.gov/pubmed/21896911.

35. Mirochnick M, Kafulafula G, et al. The pharmacokinetics (PK) of tenofovir disoproxil fumarate (TDF) after administration to HIV-1 infected pregnant women and their newborns. Paper presented at: 16th Conference on Retroviruses and Opportunistic Infections (CROI); February 8-11, 2009; Montreal, Canada. Abstract 940.

36. Tarantal AF, Castillo A, Ekert JE, Bischofberger N, Martin RB. Fetal and maternal outcome after administration of tenofovir to gravid rhesus monkeys (Macaca mulatta). *J Acquir Immune Defic Syndr*. Mar 1 2002;29(3):207-220. Available at http://www.ncbi.nlm.nih.gov/pubmed/11873070.

37. Gafni RI, Hazra R, Reynolds JC, et al. Tenofovir disoproxil fumarate and an optimized background regimen of antiretroviral agents as salvage therapy: impact on bone mineral density in HIV-infected children. *Pediatrics*. Sep 2006;118(3):e711-718. Available at http://www.ncbi.nlm.nih.gov/pubmed/16923923.

38. Schooley RT, Ruane P, Myers RA, et al. Tenofovir DF in antiretroviral-experienced patients: results from a 48-week, randomized, double-blind study. *AIDS*. Jun 14 2002;16(9):1257-1263. Available at http://www.ncbi.nlm.nih.gov/pubmed/12045491.

39. Wang Y, Livingston E, Patil S, et al. Pharmacokinetics of didanosine in antepartum and postpartum human immunodeficiency virus—infected pregnant women and their neonates: an AIDS clinical trials group study. *J Infect Dis*. 1999;180(5):1536-1541. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=10515813.

40. Bristol-Myers Squibb Company. Healthcare provider important drug warning letter. January 5, 2001. Available at http://www.bms.com.

41. Sarner L, Fakoya A. Acute onset lactic acidosis and pancreatitis in the third trimester of pregnancy in HIV-1 positive women taking antiretroviral medication. *Sex Transm Infect*. Feb 2002;78(1):58-59. Available at http://www.ncbi.nlm.nih.gov/pubmed/11872862.

42. Capparelli EV, Aweeka F, Hitti J, et al. Chronic administration of nevirapine during pregnancy: impact of pregnancy on pharmacokinetics. *HIV Med*. Apr 2008;9(4):214-220. Available at http://www.ncbi.nlm.nih.gov/pubmed/18366444.

43. Aweeka F, Lizak P, Frenkel L, et al. Steady state nevirapine pharmacokinetics during 2nd and 3rd trimester pregnancy and postpartum: PACTG 1022. Paper presented at: 11th Conference on Retroviruses and Opportunistic Infections (CROI); February 8-11, 2004; San Francisco, CA. Abstract 932.

44. Mirochnick M, Siminski S, Fenton T, Lugo M, Sullivan JL. Nevirapine pharmacokinetics in pregnant women and in their infants after in utero exposure. *Pediatr Infect Dis J*. Aug 2001;20(8):803-805. Available at http://www.ncbi.nlm.nih.gov/pubmed/11734746.

45. Baylor MS, Johann-Liang R. Hepatotoxicity associated with nevirapine use. *J Acquir Immune Defic Syndr*. 2004;35(5):538-539. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=15021321.

46. Dieterich DT, Robinson PA, Love J, Stern JO. Drug-induced liver injury associated with the use of nonnucleoside reverse-transcriptase inhibitors. *Clin Infect Dis*. 2004;38 (Suppl 2):S80-89. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=14986279.

47. Cressey TR, Stek A, Capparelli E, et al. Efavirenz pharmacokinetics during the third trimester of pregnancy and postpartum. *J Acquir Immune Defic Syndr*. 2012 Mar 1;59(3):245-52. Available at: http://www.ncbi.nlm.nih.gov/pubmed/22083071.

48. De Santis M, Carducci B, De Santis L, Cavaliere AF, Straface G. Periconceptional exposure to efavirenz and neural tube defects. *Arch Intern Med*. Feb 11 2002;162(3):355. Available at http://www.ncbi.nlm.nih.gov/pubmed/11822930.

49. Fundaro C, Genovese O, Rendeli C, Tamburrini E, Salvaggio E. Myelomeningocele in a child with intrauterine exposure to efavirenz. *AIDS*. Jan 25 2002;16(2):299-300. Available at http://www.ncbi.nlm.nih.gov/pubmed/11807320.

50. Izurieta P, Kakuda TN, Feys C, Witek J. Safety and pharmacokinetics of etravirine in pregnant HIV-1-infected women. *HIV Med*. Apr 2011;12(4):257-258. Available at http://www.ncbi.nlm.nih.gov/pubmed/21371239.

51. Ripamonti D, Cattaneo D, Maggiolo F, et al. Atazanavir plus low-dose ritonavir in pregnancy: pharmacokinetics and placental transfer. *AIDS*. Nov 30 2007;21(18):2409-2415. Available at http://www.ncbi.nlm.nih.gov/pubmed/18025877.

52. Conradie F, Zorrilla C, Josipovic D, et al. Safety and exposure of once-daily ritonavir-boosted atazanavir in HIV-infected pregnant women. *HIV Med*. 2011 Oct;12(9):570-9. Available at: http://www.ncbi.nlm.nih.gov/pubmed/21569187.

53. Mirochnick M, Stek A, Capparelli EV, et al. Pharmacokinetics of increased dose atazanavir with and without tenofovir during pregnancy. Paper presented at: 12th International Workshop on Clinical Pharmacology of HIV Therapy; April 13-16, 2011; Miami, FL.

54. Natha M, Hay P, Taylor G, et al. Atazanavir use in pregnancy: a report of 33 cases. Paper presented at: 14th Conference on Retoviruses and Opportunistic Infections (CROI); February 25-28, 2007; Los Angeles, CA. Abstract 750.

55. Cressey TR, Jourdain G, Rawangban B, et al. Pharmacokinetics and virologic response of zidovudine/lopinavir/ritonavir initiated during the third trimester of pregnancy. *AIDS*. Sep 10 2010;24(14):2193-2200. Available at http://www.ncbi.nlm.nih.gov/pubmed/20625263.

56. Stek AM, Mirochnick M, Capparelli E, et al. Reduced lopinavir exposure during pregnancy. *AIDS*. Oct 3 2006;20(15):1931-1939. Available at http://www.ncbi.nlm.nih.gov/pubmed/16988514.

57. Lambert JS, Else LJ, Jackson V, et al. Therapeutic drug monitoring of lopinavir/ritonavir in pregnancy. *HIV Med*. Mar 2011;12(3):166-173. Available at http://www.ncbi.nlm.nih.gov/pubmed/20726906.

58. Scott GB, Rodman JH, Scott WA, et al. for the PACTG 354 Protocol Team. Pharmacokinetic and virologic response to ritonavir (RTV) in combination with zidovudine (XDV) and lamivudine (3TC) in HIV-1 infected pregnant women and their infants. Paper presented at: 9th Conference on Retroviruses and Opportunistic Infections (CROI); February 24-28, 2002; Seattle, WA. Abstract 794-W. Available at http://www.retroconference.org/2002/.

59. Capparelli EV, Best BM, Stek A, et al. Pharmacokinetics of darunavir once or twice daily during pregnancy and postpartum. Paper presented at: 3rd International Workshop on HIV Pediatrics; July 15-16, 2011; Rome, Italy.

60. van der Lugt J, Colbers A, Molto J, et al. The pharmacokinetics, safety and efficacy of boosted saquinavir tablets in HIV type-1-infected pregnant women. *Antivir Ther*. 2009;14(3):443-50. Available at: http://www.ncbi.nlm.nih.gov/pubmed/19474478.

61. Unadkat JD, Wara DW, Hughes MD, et al. Pharmacokinetics and safety of indinavir in human immunodeficiency virus-infected pregnant women. *Antimicrob Agents Chemother*. Feb 2007;51(2):783-786. Available at http://www.ncbi.nlm.nih.gov/pubmed/17158945.

62. Hayashi S, Beckerman K, Homma M, Kosel BW, Aweeka FT. Pharmacokinetics of indinavir in HIV-positive pregnant women. *AIDS*. May 26 2000;14(8):1061-1062. Available at http://www.ncbi.nlm.nih.gov/pubmed/10853990.

63. Ghosn J, De Montgolfier I, Cornelie C, et al. Antiretroviral therapy with a twice-daily regimen containing 400 milligrams of indinavir and 100 milligrams of ritonavir in human immunodeficiency virus type 1-infected women during pregnancy. *Antimicrob Agents Chemother*. Apr 2008;52(4):1542-1544. Available at http://www.ncbi.nlm.nih.gov/pubmed/18250187.

64. Bryson YJ, Mirochnick M, Stek A, et al. Pharmacokinetics and safety of nelfinavir when used in combination with zidovudine and lamivudine in HIV-infected pregnant women: Pediatric AIDS Clinical Trials Group (PACTG) Protocol 353. *HIV Clin Trials*. Mar-Apr 2008;9(2):115-125. Available at http://www.ncbi.nlm.nih.gov/pubmed/18474496.

65. Villani P, Floridia M, Pirillo MF, et al. Pharmacokinetics of nelfinavir in HIV-1-infected pregnant and nonpregnant women. *Br J Clin Pharmacol*. Sep 2006;62(3):309-315. Available at http://www.ncbi.nlm.nih.gov/pubmed/16934047.

66. Read JS, Best BM, Stek AM, et al. Pharmacokinetics of new 625 mg nelfinavir formulation during pregnancy and postpartum. *HIV Med*. Nov 2008;9(10):875-882. Available at http://www.ncbi.nlm.nih.gov/pubmed/18795962.

67. Capparelli EV, Stek A, Best B, et al. Boosted fosamprenavir pharmacokinetics during Pregnancy. Paper presented at: 17th Conference on Retroviruses and Opportunistic Infections (CROI); February 16-19, 2010; San Francisco, CA. Abstract 908.

68. Weizsaecker K, Kurowski M, Hoffmeister B, Schurmann D, Feiterna-Sperling C. Pharmacokinetic profile in late pregnancy and cord blood concentration of tipranavir and enfuvirtide. *Int J STD AIDS*. May 2011;22(5):294-295. Available at http://www.ncbi.nlm.nih.gov/pubmed/21571982.

69. Brennan-Benson P, Pakianathan M, Rice P, et al. Enfurvitide prevents vertical transmission of multidrug-resistant HIV-1 in pregnancy but does not cross the placenta. *AIDS*. Jan 9 2006;20(2):297-299. Available at http://www.ncbi.nlm.nih.gov/pubmed/16511429.

70. Meyohas MC, Lacombe K, Carbonne B, Morand-Joubert L, Girard PM. Enfuvirtide prescription at the end of pregnancy to a multi-treated HIV-infected woman with virological breakthrough. *AIDS*. Sep 24 2004;18(14):1966-1968. Available at http://www.ncbi.nlm.nih.gov/pubmed/15353987.

71. Best BM, Capparelli EV, Stek A, et al. Raltegravir pharmacokinetics during pregnancy. Paper presented at: 50th Interscience Conference on Antimicrobial Agents and Chemotherapy (ICAAC); September 12-15, 2010; Boston, MA.

72. McKeown DA, Rosenvinge M, Donaghy S, et al. High neonatal concentrations of raltegravir following transplacental transfer in HIV-1 positive pregnant women. *AIDS*. Sep 24 2010;24(15):2416-2418. Available at http://www.ncbi.nlm.nih.gov/pubmed/20827058.

73. Peters PJ, Stringer J, McConnell MS, et al. Nevirapine-associated hepatotoxicity was not predicted by CD4 count ≥250 cells/muL among women in Zambia, Thailand and Kenya. *HIV Med*. Nov 2010;11(10):650-660. Available at http://www.ncbi.nlm.nih.gov/pubmed/20659176.

74. Jaworsky D, Thompson C, Yudin MH, et al. Use of newer antiretroviral agents, darunavir and etravirine with or without raltegravir, in pregnancy: a report of two cases. *Antivir Ther*. 2010;15(4):677-680. Available at http://www.ncbi.nlm.nih.gov/pubmed/20587860.

75. Ivanovic J, Bellagamba R, Nicastri E, et al. Use of darunavir/ritonavir once daily in treatment-naive pregnant woman: pharmacokinetics, compartmental exposure, efficacy and safety. *AIDS*. Apr 24 2010;24(7):1083-1084. Available at http://www.ncbi.nlm.nih.gov/pubmed/20386380.

76. Taylor N, Touzeau V, Geit M, et al. Raltegravir in pregnancy: a case series presentation. *Int J STD AIDS*. Jun 2011;22(6):358-360. Available at http://www.ncbi.nlm.nih.gov/pubmed/21680678.

77. Pinnetti C, Baroncelli S, Villani P, et al. Rapid HIV-RNA decline following addition of raltegravir and tenofovir to ongoing highly active antiretroviral therapy in a woman presenting with high-level HIV viraemia at week 38 of pregnancy. *J Antimicrob Chemother*. Sep 2010;65(9):2050-2052. Available at http://www.ncbi.nlm.nih.gov/pubmed/20630894.

## HIV-Infected Pregnant Women Who Have Never Received Antiretroviral Drugs (Antiretroviral Naive) (Last updated July 31, 2012; last reviewed July 31, 2012)

### Panel's Recommendations

- All HIV-infected pregnant women should receive a potent combination antiretroviral (ARV) regimen to reduce the risk of perinatal transmission of HIV **(AI)**. The choice of regimen should take into account current adult treatment guidelines, what is known about the use of specific drugs in pregnancy, and the risk of teratogenicity (Table 5).
- The decision as to whether to start the regimen in the first trimester or delay until 12 weeks' gestation will depend on CD4 T-lymphocyte (CD4-cell) count, HIV RNA levels, and maternal conditions such as nausea and vomiting **(AIII)**. Earlier initiation of a combination ARV regimen may be more effective in reducing transmission, but benefits must be weighed against potential fetal effects of first-trimester drug exposure.
- Combination ARV regimens should include a dual nucleoside reverse transcriptase inhibitor (NRTI) backbone that includes one or more NRTIs with high levels of transplacental passage (zidovudine, lamivudine, emtricitabine, tenofovir, or abacavir) **(AIII)**.
- ARV drug-resistance studies should be performed before starting the ARV regimen if HIV RNA is above the threshold for resistance testing (that is, >500–1,000 copies/mL) (see Antiretroviral Drug Resistance and Resistance Testing in Pregnancy) **(AI)**. If HIV is diagnosed later in pregnancy the ARV regimen should be initiated promptly without waiting for the results of resistance testing **(BIII)**.
- Nevirapine can be used as a component of the ARV regimen in pregnant women with CD4 cell counts ≤250 cells/mm$^3$. In pregnant women with CD4 cell counts >250 cells/mm$^3$, however, nevirapine should be used only if the benefit clearly outweighs the risk because the drug is associated with an increased risk of hepatic toxicity **(AII)**.

***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*

***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion*

Pregnant women with HIV infection should receive standard clinical, immunologic, and virologic evaluation.

They should be counseled about and offered combination antiretroviral (ARV) regimens containing at least 3 drugs for prevention of perinatal transmission of HIV. Use of an ARV regimen that successfully reduces plasma HIV RNA to undetectable levels substantially lowers the risk of perinatal transmission of HIV, lessens the need for consideration of elective cesarean delivery as an intervention to reduce risk of transmission, and reduces risk of ARV drug resistance in the mother. In an analysis of perinatal transmission in 5,151 HIV-infected women between 2000 and 2006 in the United Kingdom and Ireland, the overall mother-to-child transmission rate was 1.2%. A transmission rate of 0.8% was seen in women on ARV drugs for at least the last 14 days of pregnancy, regardless of the type of ARV regimen or mode of delivery.[1] After adjustment for viral load, mode of delivery, and sex of the infant, longer duration of use of ARV drugs was associated with reduced transmission rates.

The ARV regimen used in pregnancy generally should consist of two nucleoside reverse transcriptase inhibitors (NRTIs) plus a non-nucleoside reverse transcriptase inhibitor (NNRTI) or protease inhibitor (PI), consistent with the principles of treatment for non-pregnant adults but taking into account what is known about use of the drugs in pregnancy and risks of teratogenicity (see General Principles Regarding Use of Antiretroviral Drugs during Pregnancy).[2] The regimen initiated during pregnancy can be modified after delivery to include simplified regimens that were not used in pregnancy because there were insufficient pregnancy safety data or drugs may be stopped in women who do not feel prepared to continue lifelong

therapy at that point. Decisions regarding ARV use after pregnancy should be made by women in consultation with their HIV care providers, taking into account current recommendations and life circumstances (see General Principles Regarding Use of Antiretroviral Drugs during Pregnancy).

Fetuses are most susceptible to the potential teratogenic effects of drugs during the first trimester and the risks of ARV drug exposure during that period are not fully known. Therefore, women in the first trimester who do not require immediate initiation of therapy for symptomatic HIV disease can consider delaying initiation of ARV drugs until after 12 weeks' gestation. This decision should be carefully considered by health care providers and the women. The discussion should include an assessment of a woman's health status and the benefits and risks to her health of delaying initiation of ARV drugs for several weeks.

Although most perinatal transmission of HIV events occur late in pregnancy or during delivery, recent analyses suggest that early control of viral replication may be important in preventing transmission. In a recent French study, lack of early and sustained control of maternal viral load appeared strongly associated with residual perinatal transmission of HIV.[3] That study evaluated risk factors for perinatal transmission in women with HIV RNA <500 copies/mL at the time of delivery; overall HIV transmission was 0.5%. Women who transmitted were less likely to have received ARV drugs at the time of conception than were nontransmitters and were less likely to have HIV RNA <500 copies/mL at 14, 28, and 32 weeks' gestation. By multivariate analysis, plasma viral load at 30 weeks' gestation was significantly associated with transmission. Among women starting ARV drugs during pregnancy, the gestational age at initiation of therapy did not differ between groups (30 weeks), but viral load decreased earlier in the nontransmitters. The number of patients initiating therapy during pregnancy was too small to assess whether initiation of ARV drugs in the first trimester was associated with lower rates of transmission; although not statistically significant, viral load in naive women appeared to also decrease earlier in the nontransmitters. These data suggest that early and sustained control of HIV viral replication is associated with decreasing residual risk of transmission and favor initiating ARV drugs sufficiently early in naive women to suppress viral replication by the third trimester; however, this potential benefit must be balanced against the unknown long-term outcome of first-trimester drug exposure.

ARV drug-resistance testing should be performed before starting an ARV regimen if HIV RNA is above the threshold for resistance testing (that is, >500–1,000 copies/mL). For details regarding genotypic and phenotypic resistance testing, see *Guidelines for the Use of Antiretroviral Agents in HIV-1-Infected Adults and Adolescents*. Given the association of earlier viral suppression with lower risk of transmission as discussed above, if HIV is diagnosed in the second half of pregnancy the ARV regimen should be initiated promptly without waiting for the results of resistance testing. Because clinically significant resistance to PIs is less common than resistance to NNRTIs in ARV-naive individuals, a PI-based ARV drug regimen generally should be considered in this situation.

ARV prophylaxis is recommended for all pregnant women with HIV infection, regardless of viral load. Although rates of perinatal transmission are low in women with undetectable or low HIV RNA levels, there is no threshold below which lack of transmission can be ensured.[4-6] The mechanism by which ARV drugs reduce perinatal transmission of HIV is multifactorial. Although lowering maternal antenatal viral load is an important component of prevention in women with higher viral load, ARV prophylaxis is effective even in women with low viral load.[7-11] Additional mechanisms of protection include pre-exposure prophylaxis (PrEP) and post-exposure prophylaxis of the infant. With PrEP, passage of the ARV drug across the placenta results in presence of drug levels sufficient for inhibition of viral replication in the fetus, particularly during the birth process when there is intensive viral exposure. Therefore, whenever possible, combination ARV drug regimens initiated during pregnancy should include zidovudine or another NRTI with high transplacental passage, such as lamivudine, emtricitabine, tenofovir, or abacavir (see Table 5).[12-15] With post-exposure prophylaxis, ARV drugs are administered to the infant after birth.

Use of nevirapine in pregnancy requires special consideration. A review of a large database of nevirapine studies indicated that women with CD4 cell counts >250 cells/mm$^3$ have an increased risk of developing symptomatic, often rash-associated, nevirapine-related hepatotoxicity that can be severe, life threatening, and in some cases fatal.[16, 17] A more recent study involving 820 women in Kenya, Zambia, and Thailand, however, did not find an association between CD4 cell count and development of hepatotoxicity.[18] Increased risk of rash and liver toxicity were associated with elevated baseline liver transaminases but not with CD4 cell count; all deaths from hepatic toxicity occurred in women with CD4 cell counts <100 cells/mm$^3$ at baseline on concomitant anti-tuberculosis therapy. In women with CD4 cell counts >250 cells/mm$^3$, nevirapine should be used as a component of a combination ARV regimen only when the benefit clearly outweighs the risk. If nevirapine is used, baseline and frequent monitoring of transaminase levels is required, particularly during the first 18 weeks of treatment (see Nevirapine and Hepatic/Rash Toxicity). Transaminase levels should be checked before starting nevirapine and again in women who develop a rash. Nevirapine should be stopped immediately in women who develop signs or symptoms of hepatitis.

The use of raltegravir in late pregnancy for women who have high viral loads has been suggested because of its ability to rapidly suppress viral load (approximately 2-log copies/mL decrease by Week 2 of therapy).[19-22] However, the efficacy and safety of this approach have not been evaluated and only anecdotal reports are available. Until more data become available on the safety of raltegravir use in pregnancy, this approach cannot be recommended for therapy-naive women.

Some women may wish to restrict fetal exposure to ARV drugs while reducing the risk of HIV transmission to their infants. Use of zidovudine alone during pregnancy for prophylaxis of perinatal transmission is not optimal, but it could be an option for women with low viral loads (that is, <1,000 copies/mL) on no ARV drugs. In the U.K. study discussed above, transmission rates were 0.7% for women receiving a triple-ARV drug regimen combined with planned cesarean delivery or with planned vaginal delivery and 0.5% in 464 women with HIV RNA levels below 10,000 copies/mL who received single-drug prophylaxis with zidovudine combined with planned cesarean delivery, not significantly different between groups. Zidovudine single-drug prophylaxis is recommended in the British HIV Association guidelines for women with HIV RNA levels <10,000 copies/mL and wild-type virus who do not require treatment for their own health.[23] Time-limited administration of zidovudine during the second and third trimesters is less likely to induce development of resistance in women with low viral loads than in those with higher viral loads. This lower rate of resistance is likely because of the low level of viral replication and the short duration of exposure.[24, 25] Women's choices after counseling to use or not use ARV drugs during pregnancy should be respected.

After delivery, considerations regarding continuation of the ARV regimen for treatment in mothers are the same as in other non-pregnant adults (see General Principles Regarding Use of Antiretroviral Drugs during Pregnancy).

## References


1. Townsend CL, Cortina-Borja M, Peckham CS, de Ruiter A, Lyall H, Tookey PA. Low rates of mother-to-child transmission of HIV following effective pregnancy interventions in the United Kingdom and Ireland, 2000-2006. *AIDS*. May 11 2008;22(8):973-981. Available at http://www.ncbi.nlm.nih.gov/pubmed/18453857.
2. Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents. Department of Health and Human Services. Available at http://aidsinfo.nih.gov/contentfiles/lvguidelines/AdultandAdolescentGL.pdf. Accessed June 7, 2012.
3. Tubiana R, Le Chenadec J, Rouzioux C, et al. Factors associated with mother-to-child transmission of HIV-1 despite a maternal viral load <500 copies/ml at delivery: a case-control study nested in the French perinatal cohort (EPF-ANRS CO1). *Clin Infect Dis*. Feb 15 2010;50(4):585-596. Available at http://www.ncbi.nlm.nih.gov/pubmed/20070234.

4. Cooper ER, Charurat M, Mofenson L, et al. Combination antiretroviral strategies for the treatment of pregnant HIV-1-infected women and prevention of perinatal HIV-1 transmission. *J Acquir Immune Defic Syndr*. Apr 15 2002;29(5):484-494. Available at http://www.ncbi.nlm.nih.gov/pubmed/11981365.

5. Mofenson LM, Lambert JS, Stiehm ER, et al. Risk factors for perinatal transmission of human immunodeficiency virus type 1 in women treated with zidovudine. Pediatric AIDS Clinical Trials Group Study 185 Team. *N Engl J Med*. Aug 5 1999;341(6):385-393. Available at http://www.ncbi.nlm.nih.gov/pubmed/10432323.

6. Garcia PM, Kalish LA, Pitt J, et al. Maternal levels of plasma human immunodeficiency virus type 1 RNA and the risk of perinatal transmission. Women and Infants Transmission Study Group. *N Engl J Med*. Aug 5 1999;341(6):394-402. Available at http://www.ncbi.nlm.nih.gov/pubmed/10432324.

7. Ioannidis JP, Abrams EJ, Ammann A, et al. Perinatal transmission of human immunodeficiency virus type 1 by pregnant women with RNA virus loads <1000 copies/ml. *J Infect Dis*. Feb 15 2001;183(4):539-545. Available at http://www.ncbi.nlm.nih.gov/pubmed/11170978.

8. Wade NA, Birkhead GS, Warren BL, et al. Abbreviated regimens of zidovudine prophylaxis and perinatal transmission of the human immunodeficiency virus. *N Engl J Med*. Nov 12 1998;339(20):1409-1414. Available at http://www.ncbi.nlm.nih.gov/pubmed/9811915.

9. Jackson JB, Musoke P, Fleming T, et al. Intrapartum and neonatal single-dose nevirapine compared with zidovudine for prevention of mother-to-child transmission of HIV-1 in Kampala, Uganda: 18-month follow-up of the HIVNET 012 randomised trial. *Lancet*. Sep 13 2003;362(9387):859-868. Available at http://www.ncbi.nlm.nih.gov/pubmed/13678973.

10. Petra Study Team. Efficacy of three short-course regimens of zidovudine and lamivudine in preventing early and late transmission of HIV-1 from mother to child in Tanzania, South Africa, and Uganda (Petra study): a randomised, double-blind, placebo-controlled trial. *Lancet*. Apr 6 2002;359(9313):1178-1186. Available at http://www.ncbi.nlm.nih.gov/pubmed/11955535.

11. Moodley D, Moodley J, Coovadia H, et al. A multicenter randomized controlled trial of nevirapine versus a combination of zidovudine and lamivudine to reduce intrapartum and early postpartum mother-to-child transmission of human immunodeficiency virus type 1. *J Infect Dis*. Mar 1 2003;187(5):725-735. Available at http://www.ncbi.nlm.nih.gov/pubmed/12599045.

12. Hirt D, Urien S, Rey E, et al. Population pharmacokinetics of emtricitabine in human immunodeficiency virus type 1-infected pregnant women and their neonates. *Antimicrob Agents Chemother*. Mar 2009;53(3):1067-1073. Available at http://www.ncbi.nlm.nih.gov/pubmed/19104016.

13. Hirt D, Urien S, Ekouevi DK, et al. Population pharmacokinetics of tenofovir in HIV-1-infected pregnant women and their neonates (ANRS 12109). *Clin Pharmacol Ther*. Feb 2009;85(2):182-189. Available at http://www.ncbi.nlm.nih.gov/pubmed/18987623.

14. Moodley D, Pillay K, Naidoo K, et al. Pharmacokinetics of zidovudine and lamivudine in neonates following coadministration of oral doses every 12 hours. *J Clin Pharmacol*. Jul 2001;41(7):732-741. Available at http://www.ncbi.nlm.nih.gov/pubmed/11452705.

15. Wade NA, Unadkat JD, Huang S, et al. Pharmacokinetics and safety of stavudine in HIV-infected pregnant women and their infants: Pediatric AIDS Clinical Trials Group protocol 332. *J Infect Dis*. Dec 15 2004;190(12):2167-2174. Available at http://www.ncbi.nlm.nih.gov/pubmed/15551216.

16. Stern JO, Robinson PA, Love J, Lanes S, Imperiale MS, Mayers DL. A comprehensive hepatic safety analysis of nevirapine in different populations of HIV infected patients. *J Acquir Immune Defic Syndr*. Sep 2003;34(Suppl 1):S21-33. Available at http://www.ncbi.nlm.nih.gov/pubmed/14562855.

17. Boehringer-Ingelheim Pharmaceuticals Inc. Viramune drug label. March 25, 2011. Available at http://www.accessdata.fda.gov/drugsatfda_docs/label/2011/020933s028,020636s037lbl.pdf.

18. Peters PJ, Stringer J, McConnell MS, et al. Nevirapine-associated hepatotoxicity was not predicted by CD4 count ≥250 cells/muL among women in Zambia, Thailand and Kenya. *HIV Med*. Nov 2010;11(10):650-660. Available at http://www.ncbi.nlm.nih.gov/pubmed/20659176.

19. Grinsztejn B, Nguyen BY, Katlama C, et al. Safety and efficacy of the HIV-1 integrase inhibitor raltegravir (MK-0518) in treatment-experienced patients with multidrug-resistant virus: a phase II randomised controlled trial. *Lancet*. Apr 14 2007;369(9569):1261-1269. Available at http://www.ncbi.nlm.nih.gov/pubmed/17434401.

20. Papendorp SG, van den Berk GE. Preoperative use of raltegravir-containing regimen as induction therapy: very rapid decline of HIV-1 viral load. *AIDS*. Mar 27 2009;23(6):739. Available at http://www.ncbi.nlm.nih.gov/pubmed/19279447.

21. Pinnetti C, Baroncelli S, Villani P, et al. Rapid HIV-RNA decline following addition of raltegravir and tenofovir to ongoing highly active antiretroviral therapy in a woman presenting with high-level HIV viraemia at week 38 of pregnancy. *J Antimicrob Chemother*. Sep 2010;65(9):2050-2052. Available at http://www.ncbi.nlm.nih.gov/pubmed/20630894.

22. McKeown DA, Rosenvinge M, Donaghy S, et al. High neonatal concentrations of raltegravir following transplacental transfer in HIV-1 positive pregnant women. *AIDS*. Sep 24 2010;24(15):2416-2418. Available at http://www.ncbi.nlm.nih.gov/pubmed/20827058.

23. de Ruiter A, Taylor GP, Clayden P, et al for the British HIV Association. Guidelines for the management of HIV infection in pregnant women 2012. Available at http://www.bhiva.org/documents/Guidelines/treatment/2012/120430pregnancyguidelines.pdf. Accessed on July 5, 2012.

24. Read P, Costelloe S, Mullen J, et al. New mutations associated with resistance not detected following zidovudine monotherapy in pregnancy when used in accordance with British HIV Association guidelines. *HIV Med*. Aug 2008;9(7):448-451. Available at http://www.ncbi.nlm.nih.gov/pubmed/18840150.

25. Larbalestier N, Mullen J, O'Shea S, et al. Drug resistance is uncommon in pregnant women with low viral loads taking zidovudine monotherapy to prevent perinatal HIV transmission. *AIDS*. Dec 5 2003;17(18):2665-2667. Available at http://www.ncbi.nlm.nih.gov/pubmed/14685064.

## HIV-Infected Pregnant Women Who Are Currently Receiving Antiretroviral Therapy (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendations |
|---|
| • In general, HIV-infected women receiving antiretroviral therapy (ART) who present for care during the first trimester should continue treatment during pregnancy, assuming the regimen is tolerated and effective in suppressing viral replication **(AII)**. The Panel recommends that efavirenz be continued in pregnant women receiving efavirenz-based ART who present for antenatal care in the first trimester provided the regimen is resulting in virologic suppression (see text) **(CIII)**. |
| • Pregnant women receiving and tolerating nevirapine-containing regimens who are virologically suppressed should continue the regimen, regardless of CD4 count **(AIII)**. |
| • HIV antiretroviral drug-resistance testing is recommended for pregnant women who have detectable viremia (that is, >500–1,000 copies/mL) on therapy (see Failure of Viral Suppression) **(AI)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

In general, women who have been receiving antiretroviral therapy (ART) for their HIV infection should continue that treatment during pregnancy, assuming it is tolerated and effective in suppressing viral replication. Discontinuation of therapy could lead to an increase in viral load with possible decline in immune status and disease progression as well as adverse consequences for the fetus, including increased risk of HIV transmission. Continuation of therapy, therefore, is recommended when pregnancy is identified in HIV-infected women receiving ART.

HIV-infected women receiving ART who present for care during the first trimester should be counseled regarding the benefits and potential risks of administration of antiretroviral (ARV) drugs during this period and that continuation of ART is recommended. There are concerns regarding efavirenz use in the first trimester of pregnancy and potential for neural tube defects, based on preclinical primate data and retrospective case reports (for more details see Special Considerations Regarding the Use of Antiretroviral Drugs by HIV-Infected Pregnant Women and their Infants: Teratogenicity). A recent meta-analysis including data on 1,437 women with first-trimester efavirenz exposure from 19 prospective studies did not find an increased relative risk (RR) of overall birth defects in infants born to women receiving efavirenz-based versus non-efavirenz–based regimens (RR 0.85, 95% confidence interval [CI], 0.6–1.2) and identified 1 neural tube defect, resulting in an incidence of 0.07% (95% CI, 0.002–0.39%).[1] Although a 2- to 3-fold increased incidence of a rare outcome (such as neural tube defects [0.02%–0.2% incidence in the United States]) cannot be ruled out given the limited data on first-trimester efavirenz exposure, the available data suggest that first-trimester exposure is not associated with a large (that is, 10-fold or more) increase in risk of neural tube defects. Analyses from the Italian Group on Surveillance on Antiretroviral Treatment in Pregnancy found that treatment changes during pregnancy significantly increased the risk of incomplete viral suppression at the end of pregnancy.[2] The risk of neural tube defects is restricted to the first 5 to 6 weeks of pregnancy (the neural tube closes at 36–39 days after last menstrual period), pregnancy is rarely recognized before 4 to 6 weeks of pregnancy, and unnecessary changes of ARV drugs in pregnancy may be associated with loss of viral control and, thus, increase risk of transmission to the infant. Therefore, the Panel recommends that efavirenz be continued in pregnant women receiving efavirenz-based ART who present for antenatal care in the first trimester, provided that the regimen is resulting in virologic suppression. In such

situations, additional fetal monitoring (such as with second-trimester ultrasound) should be considered to evaluate fetal anatomy.

Resistance testing should be performed in women who are on therapy but in whom viral replication is not fully suppressed. The results can be used to select a new regimen with a greater likelihood of suppressing viral replication to undetectable levels. Drug resistance testing is generally done in individuals with HIV RNA levels >1,000 copies/mL; however, in persons with HIV RNA levels >500 but <1,000 copies/mL, testing may be unsuccessful but should still be considered.

Pregnant women for whom nevirapine-containing regimens are achieving virologic suppression and who are tolerating therapy may be continued on that regimen, regardless of current CD4 T-lymphocyte (CD4-cell) count. Although hepatic toxicity is a concern in women starting a nevirapine-containing regimen who have CD4-cell counts >250 cells/mm$^3$, an increased risk of hepatic toxicity has not been seen in women receiving nevirapine-based therapy in whom the therapy has produced immune reconstitution.

## References


1. Ford N, Calmy A, Mofenson L. Safety of efavirenz in the first trimester of pregnancy: an updated systematic review and meta-analysis. *AIDS*. Nov 28 2011;25(18):2301-2304. Available at http://www.ncbi.nlm.nih.gov/pubmed/21918421.
2. Floridia M, Ravizza M, Pinnetti C, et al. Treatment change in pregnancy is a significant risk factor for detectable HIV-1 RNA in plasma at end of pregnancy. *HIV Clin Trials*. Nov-Dec 2010;11(6):303-311. Available at http://www.ncbi.nlm.nih.gov/pubmed/21239358.

## HIV-Infected Pregnant Women Who Have Previously Received Antiretroviral Treatment or Prophylaxis but Are Not Currently Receiving Any Antiretroviral Medications (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendations |
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| • Obtain an accurate history of all prior antiretroviral (ARV) regimens used for treatment of HIV disease or prevention of transmission, including virologic efficacy, tolerance to the medications, results of prior resistance testing, and any adherence issues **(AIII)**. |
| • If HIV RNA is above the threshold for resistance testing (that is, >500–1,000 copies/mL), ARV drug-resistance studies should be performed before starting an ARV drug regimen (see Antiretroviral Drug Resistance and Resistance Testing in Pregnancy) **(AIII)**. In women who present late in pregnancy, therapy or prophylaxis should be initiated promptly without waiting for the results of resistance testing **(BIII)**. |
| • Choose and initiate a combination ARV drug regimen based on results of resistance testing and prior history of antiretroviral therapy while avoiding drugs with teratogenic potential or with known adverse potential for the mother **(AII)**. |
| • Consult specialists in treatment of HIV infection about the choice of a combination ARV regimen in women who previously received ARV drugs for their own health **(AIII)**. |
| • Perform repeat ARV drug-resistance testing **(AI)**, assess adherence, and consult with an HIV treatment specialist to guide changes in ARV drugs in women who do not achieve virologic suppression on their ARV regimens (see Monitoring of the Woman and Fetus During Pregnancy). |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

During a previous pregnancy, HIV-infected women may have received antiretroviral (ARV) drugs solely for prevention of perinatal transmission. At any time in the past, they also may have discontinued ARV drugs given to them for treatment of their own disease. A small number of clinical trials or observational studies have generated information about how effective antiretroviral therapy (ART) is in individuals who previously received ARV prophylaxis. The data are limited to outcomes with therapy containing nevirapine initiated after the use of peripartum single-dose nevirapine.[1-5]

Initial reports suggested a diminished virologic and clinical response to nevirapine-based ART if therapy was initiated within 6 months of intrapartum single-dose nevirapine exposure.[1-3] Subsequent reports have confirmed that a shorter interval between intrapartum single-dose nevirapine exposure and initiation of therapy with ART regimens containing nevirapine is associated with decreased efficacy of therapy and suggested that the diminished response may persist 12 to 24 months after exposure.[4, 5] In addition, the subsequent failure of non-nucleoside reverse transcriptase inhibitor (NNRTI)-based ART after single-dose nevirapine has been associated with lower CD4 T-lymphocyte (CD4-cell) count and higher HIV-RNA plasma concentration at the time of single-dose nevirapine exposure and genotypic resistance to nevirapine. However, in a retrospective analysis of virologic suppression rates after initiation of an efavirenz-based ART regimen within 24 months of receipt of intrapartum single-dose nevirapine for prevention of perinatal transmission, no difference was seen between cases and controls who had never received single-dose nevirapine. Efficacy was similar when therapy was initiatied within and after 6 months of single-dose nevirapine.[6] Adding other ARV drugs to single-dose nevirapine (such as use of an ARV "tail") decreases rates of nevirapine resistance[7, 8] (see Antiretroviral Drug Resistance and Resistance Testing in Pregnancy), but the

effect on clinical response of subsequent initiation of NNRTI-based ART is unknown.

There is concern that time-limited use of ARV drugs during pregnancy for prophylaxis of perinatal transmission may lead to genotypic resistance and, thus, reduced efficacy of these ARV drugs when used either for indicated HIV therapy in a woman or during a subsequent pregnancy for prevention of perinatal transmission. Rates of resistance appear to be low, based on standard genotyping, after prophylaxis for prevention of perinatal transmission with combination ARVs consisting of zidovudine, lamivudine, and nevirapine.[9, 10] However, minority populations of virus with resistance to nevirapine or lamivudine have been detected using sensitive allele-specific polymerase chain reaction (PCR) techniques, particularly in women whose virus was inadequately suppressed during prophylaxis.[10-12] Only limited data are available on the impact of these resistance-conferring minority variants on prediction of virologic or clinical failure of subsequent ART, and the PCR-based assays are not widely available. Both standard and sensitive genotyping techniques appear to show a low rate of resistance to protease inhibitors (PIs) after pregnancy-limited use of PI-based combination ARV regimens for prophylaxis, but these results reflect assessments in only small numbers of women.[12, 13]

To date, treatment failure has not been demonstrated with reinitiation of combination ARV regimens following prophylactic use in pregnancy for prevention of transmission. In ACTG 5227, 52 women who had previously received combination ARV regimens for prevention of perinatal transmission, had no evidence of HIV drug resistance, and had an indication for restarting ART were prescribed a fixed-dose combination of efavirenz plus tenofovir/emtricitabine once daily. After 6 months of therapy, 81% achieved plasma viral loads below the limit of detection; the virologic suppression rate was similar regardless of the drug class of the prior combination ARV regimen and whether women had received such ARV regimens in 1 or more than 1 previous pregnancy.[14] Data from the French Perinatal Cohort assessed virologic suppression with a PI-based combination ARV regimen administered for prevention of perinatal transmission to women who had received ARV prophylaxis during a previous pregnancy. No differences in rates of undetectable viral load at delivery were noted among ARV-naive women when compared with those with previous prophylaxis or according to type of previous prophylaxis regimens received.[15] In addition, the United Kingdom and Ireland-based National Study of HIV in Pregnancy and Childhood found no increased risk of perinatal transmission in sequential pregnancies compared with 1 pregnancy at a time when most women received interventions for prevention of perinatal HIV transmission.[16] However, sufficiently large, prospective, observational studies and clinical trials are lacking to show that pregnancy-limited ARV prophylaxis has no effect on virologic outcome of subsequent ART.

Given the lack of substantive data, it is reasonable to use results of initial resistance testing, if available, to make preliminary decisions about ARV regimens in women whose only previous exposure to ARV drugs was during pregnancy for prophylaxis of perinatal transmission. However, interpretation of resistance testing after discontinuation of ARV drugs can be complex because drug-resistance testing is most accurate if performed while an individual is taking the ARV regimen or within 4 weeks of treatment discontinuation. In the absence of selective drug pressure, resistant virus may revert to wild-type virus, and although detection of drug-resistance mutations is informative for choosing a regimen, a negative finding does not rule out the presence of archived drug-resistant virus that could re-emerge once drugs are reinitiated. Therefore, when selecting a new regimen for use during the current pregnancy, all information from the previous pregnancy—including regimens received, viral response, laboratory testing (including HLA-B*5701 results), and any tolerance or adherence issues—and the results of resistance testing should be taken into consideration. In women who present late in pregnancy, therapy or prophylaxis should be initiated pending results of resistance testing. Careful monitoring of virologic response to the chosen ARV regimen is important.

If the chosen regimen produces an insufficient viral response, decisions about switching regimens should be guided by repeat resistance testing and assessment of medication adherence. These measures should be undertaken in consultation with an HIV treatment specialist.

Some women who receive ART for their own health choose to discontinue the drugs for a variety of reasons, and the length of time between treatment termination and pregnancy may vary. In these cases, careful clinical and laboratory assessments are necessary before therapy is reinitiated during pregnancy. The evaluations should include a review of a woman's prior history of virologic response and medication toxicity and her adherence to therapy. The appropriate choice of ARV regimen to be initiated during pregnancy will vary according to a woman's history of ART; the indication for stopping therapy; the effect of prior therapy on clinical, virologic, and immunologic status; and the results of past and current testing for resistance and for HLA-B*5701. It may be possible, for example, to restart the same regimen in women with a history of prior ART associated with successful suppression of viral load who then stopped all drugs simultaneously (or staggered discontinuation, if therapy was NNRTI based) and who have no evidence of resistance. On the other hand, the selection of an appropriate ARV regimen may be challenging even for health care providers experienced in HIV care in women with advanced HIV disease, a history of extensive prior ART, or previous significant toxicity or nonadherence to ARV drugs. In such cases, restarting the prior regimen for a week or two before performing a resistance assay may yield more accurate results. In addition to obtaining genotypic resistance testing, it is strongly recommended that specialists in the treatment of HIV infection be consulted early during the pregnancy about the choice of a suitable combination ARV regimen.

## References


1. Lockman S, Shapiro RL, Smeaton LM, et al. Response to antiretroviral therapy after a single, peripartum dose of nevirapine. *N Engl J Med*. Jan 11 2007;356(2):135-147. Available at http://www.ncbi.nlm.nih.gov/pubmed/17215531.
2. Coovadia A, Hunt G, Abrams E, et al. Peristent minority K103N mutations among women exposed to single-dose nevirapine and virologic response to nonnucleotide reverse-transcriptase inhibitor-based therapy. *Clin Infect Dis*. 2009 Feb 15;48(4)462-72. Available at: http://www.ncbi.nlm.nih.gov/pubmed/19133804.
3. Chi BH, Sinkala M, Stringer EM, et al. Early clinical and immune response to NNRTI-based antiretroviral therapy among women with prior exposure to single-dose nevirapine. *AIDS*. May 11 2007;21(8):957-964. Available at http://www.ncbi.nlm.nih.gov/pubmed/17457089.
4. Lockman S, Hughes MD, McIntyre J, et al. Antiretroviral therapies in women after single-dose nevirapine exposure. *N Engl J Med*. Oct 14 2010;363(16):1499-1509. Available at http://www.ncbi.nlm.nih.gov/pubmed/20942666.
5. Stringer JS, McConnell MS, Kiarie J, et al. Effectiveness of non-nucleoside reverse-transcriptase inhibitor-based antiretroviral therapy in women previously exposed to a single intrapartum dose of nevirapine: a multi-country, prospective cohort study. *PLoS Med*. Feb 2010;7(2):e1000233. Available at http://www.ncbi.nlm.nih.gov/pubmed/20169113.
6. Bolhaar MG, Karstaedt AS. Efavirenz-based combination antiretroviral therapy after peripartum single-dose nevirapine. *Int J STD AIDS*. Jan 2011;22(1):38-42. Available at http://www.ncbi.nlm.nih.gov/pubmed/21364065.
7. Chi BH, Sinkala M, Mbewe F, et al. Single-dose tenofovir and emtricitabine for reduction of viral resistance to non-nucleoside reverse transcriptase inhibitor drugs in women given intrapartum nevirapine for perinatal HIV prevention: an open-label randomised trial. *Lancet*. Nov 17 2007;370(9600):1698-1705. Available at http://www.ncbi.nlm.nih.gov/pubmed/17997151.
8. McIntyre JA, Hopley M, Moodley D, et al. Efficacy of short-course AZT plus 3TC to reduce nevirapine resistance in the prevention of mother-to-child HIV transmission: a randomized clinical trial. *PLoS Med*. 2009 Oct;6(10):e1000172. Available at: http://www.ncbi.nlm.nih.gov/pubmed/19859531.
9. Perez H, Vignoles M, Laufer N, et al. Low rate of emergence of nevirapine and lamivudine resistance after post-partum interruption of a triple-drug regimen. *Antivir Ther*. 2008;13(1):135-139. Available at http://www.ncbi.nlm.nih.gov/pubmed/18389908.
10. Lehman DA, Chung MH, Mabuka JM, et al. Lower risk of resistance after short-course HAART compared with zidovudine/single-dose nevirapine used for prevention of HIV-1 mother-to-child transmission. *J Acquir Immune Defic*

*Syndr*. Aug 15 2009;51(5):522-529. Available at http://www.ncbi.nlm.nih.gov/pubmed/19502990.

11. Rowley CF, Boutwell CL, Lee EJ, et al. Ultrasensitive detection of minor drug-resistant variants for HIV after nevirapine exposure using allele-specific PCR: clinical significance. *AIDS Res Hum Retroviruses*. Mar 2010;26(3):293-300. Available at http://www.ncbi.nlm.nih.gov/pubmed/20334564.
12. Paredes R, Cheng I, Kuritzkes DR, Tuomala RE, Women, Infants Transmission Study Group. Postpartum antiretroviral drug resistance in HIV-1-infected women receiving pregnancy-limited antiretroviral therapy. *AIDS*. Jan 2 2010;24(1):45-53. Available at http://www.ncbi.nlm.nih.gov/pubmed/19915448.
13. Gingelmaier A, Eberle J, Kost BP, et al. Protease inhibitor-based antiretroviral prophylaxis during pregnancy and the development of drug resistance. *Clin Infect Dis*. Mar 15 2010;50(6):890-894. Available at http://www.ncbi.nlm.nih.gov/pubmed/20166821.
14. Vogler MA, Smeaton L, et al. Effect of prior cART used only to prevent MTCT of HIV-1 on subsequent cART efficacy in HIV+ women restarting HIV therapy with a standard first-line regimen: ACTG A5227 study. Paper presented at: 18th Conference on Retroviruses and Opportunistic Infections (CROI); February 27-March 2, 2011; Boston, MA. Abstract 752.
15. Briand N, Mandelbrot L, Blanche S, et al. Previous antiretroviral therapy for prevention of mother-to-child transmission of HIV does not hamper the initial response to PI-based multitherapy during subsequent pregnancy. *J Acquir Immune Defic Syndr*. Jun 1 2011;57(2):126-135. Available at http://www.ncbi.nlm.nih.gov/pubmed/21436712.
16. French C, Thorne C, et al.Are sequential pregnancies in HIV+ women associated with an increased risk of MTCT. Paper presented at: 18th Conference on Retroviruses and Opportunistic Infections (CROI) February 27-March 2, 2011; Boston, MA. Abstract 736.

## Special Situations — HIV/Hepatitis B Virus Coinfection (Last updated July 31, 2012; last reviewed July 31, 2012)

### Panel's Recommendations

- Screening for hepatitis B virus (HBV) infection with hepatitis B surface antigen (HBsAg), hepatitis B core antibody (anti-HBc), and hepatitis B surface antibody (anti-HBs) is recommended for all pregnant women who have not been screened during the current pregnancy **(AII)**.
- The HBV vaccine series should be administered to pregnant women who screen negative for hepatitis B (that is, HBsAg negative, anti-HBc negative, and anti-HBs negative) **(AII)**.
- Pregnant women with chronic HBV infection should be screened for antibodies to hepatitis A virus (HAV), and those who screen negative should receive the HAV vaccine series **(AII)**.
- Interferon alfa and pegylated interferon alfa are not recommended during pregnancy **(AIII)**.
- The management of HIV/HBV coinfection in pregnancy is complex and consultation with an expert in HIV and HBV is strongly recommended **(AIII)**.
- All pregnant women with HIV/HBV coinfection should receive antiretroviral therapy (ART), including a dual nucleoside reverse transcriptase inhibitor (NRTI)/nucleotide analogue reverse transcriptase inhibitor (NtRTI) backbone with two drugs active against both HIV and HBV **(AII)**. Tenofovir plus lamivudine or emtricitabine is the preferred dual NRTI/NtRTI backbone of antepartum ART in HIV/HBV-coinfected pregnant women **(AI)**.
- If antiretroviral (ARV) drugs are discontinued postpartum in women with HIV/HBV coinfection, frequent monitoring of liver function tests for potential exacerbation of HBV infection is recommended, with prompt reinitiation of treatment for both HIV and HBV if a flare is suspected **(BIII)**.
- Pregnant women with HIV/HBV coinfection receiving ARV drugs should be counseled about the signs and symptoms of liver toxicity, and liver transaminases should be assessed 1 month following initiation of ARV drugs and at least every 3 months thereafter **(BIII)**.
- Within 12 hours of birth, infants born to women with HBV infection should receive hepatitis B immune globulin and the first dose of the HBV vaccine series. The second and third doses of vaccine should be administered at ages 1 and 6 months, respectively **(AI)**.

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***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*

***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion*

For additional information on hepatitis B and HIV, see *HIV/Hepatitis B (HBV) Coinfection* in *Guidelines for the Use of Antiretroviral Agents in HIV-1-Infected Adults and Adolescents* (http://AIDSinfo.nih.gov)[1] and *Hepatitis B Virus Infection* in the *Guidelines for Prevention and Treatment of Opportunistic Infections in HIV-Infected Adults and Adolescents, Recommendations from the Centers for Disease Control and Prevention (CDC), the National Institutes of Health (NIH), and the HIV Medicine Association of the Infectious Diseases Society of America*.[2]

All HIV-infected pregnant women should be screened for hepatitis A, B, and C. The management of HIV/hepatitis B virus (HBV) coinfection in pregnancy is complex and consultation with an expert in HIV and HBV infection is strongly recommended. HIV-infected women who are found to have chronic HBV infection on the basis of persistent hepatitis B surface antigenemia for at least 6 months and who are hepatitis A immunoglobulin G negative should receive the hepatitis A virus (HAV) vaccine series because of the

added risk of acute hepatitis A in persons with chronic viral hepatitis. Although the safety of HAV vaccination during pregnancy has not been determined, HAV vaccine is produced from inactivated HAV and the theoretical risk to the developing fetus is expected to be low.[3]

HIV-infected pregnant women who test negative for hepatitis B surface antibody (anti-HBs) and hepatitis B surface antigen (HBsAg) should receive the HBV vaccine series. Limited data indicate no apparent risk to developing fetuses of adverse events from hepatitis B vaccine, and current vaccines contain noninfectious HBsAg and should cause no risk to fetuses.[3] A positive test for hepatitis B core antibody (anti-HBc) alone can be a false-positive result, or it may signify past exposure with subsequent loss of anti-HBs or "occult" HBV infection, which can be confirmed by detection of HBV DNA.[4, 5] The clinical significance of isolated anti-HBc is unknown.[6, 7] Some experts recommend that HIV-infected individuals with anti-HBc alone be tested for HBV DNA before vaccination for HBV or before treatment or prophylaxis with antiretroviral (ARV) drugs is initiated because of the risk of a paradoxical exacerbation of HBV and the occurrence of immune reconstitution inflammatory syndrome (IRIS).[2]

An ARV regimen that includes drugs active against both HIV and HBV is recommended for all individuals with HIV/HBV coinfection who require HBV treatment or who are starting ARV drugs, including pregnant women. Initiation of an ARV regimen that does not include anti-HBV drugs may be associated with reactivation of HBV and development of IRIS; IRIS-related flare of HBV activity during pregnancy can occur even in women with relatively high CD4 T-lymphocyte (CD4-cell) counts at the time of ARV initiation. In addition, use of ARV drugs with anti-HBV activity during pregnancy lowers HBV viremia, potentially increasing the efficacy of neonatal hepatitis B immune globulin (HBIG) and hepatitis B vaccine in prevention of perinatal transmission of HBV. High maternal HBV DNA levels are strongly correlated with perinatal HBV transmission and with failures of HBV passive-active immunoprophylaxis.[8-10] Several small studies suggest that lamivudine or telbivudine may reduce the risk of perinatal transmission of HBV if given during the third trimester to HBV-infected, HIV-seronegative women with high HBV DNA viremia.[11-14] Although a high HBV viral load clearly is important, it is not the only factor predisposing to failure of prophylaxis.[15]

Because lamivudine, tenofovir, and emtricitabine have activity against both HIV and HBV, the recommended dual-nucleoside reverse transcriptase (NRTI)/nucleotide analogue reverse transcriptase inhibitor (NtRTI) backbone for HIV/HBV-coinfected individuals, including pregnant women, is tenofovir/emtricitabine or tenofovir/lamivudine. Lamivudine has been extensively studied and is recommended for use in pregnancy (Table 5). The Antiretroviral Pregnancy Registry includes reports on the outcomes of 4,088 pregnancies that involved administration of lamivudine in the first trimester and there is no indication that the exposure was associated with an increased risk of birth defects.[16] Similarly, no increase in birth defects has been noted in 899 cases of first-trimester exposure to emtricitabine, which is an alternative NRTI for use in pregnancy (Table 5). Tenofovir is not teratogenic in animals, but reversible bone changes at high doses have been seen in multiple animal species. A total of 1,370 cases of first-trimester exposure have been reported to the Antiretroviral Pregnancy Registry, with no increase in birth defects noted.[16] Although tenofovir is recommended as an alternative NtRTI during pregnancy for ARV-naive women, it is a preferred NtRTI in women with HIV/HBV coinfection (Table 5).

Several other antivirals with activity against HBV, including entecavir, adefovir, and telbivudine, have had minimal evaluation in pregnancy. Entecavir is associated with skeletal anomalies in rats and rabbits but only at doses high enough to cause toxicity to the mother. Fewer than 70 cases of exposure to each of these drugs during pregnancy have been reported to the Antiretroviral Pregnancy Registry.[16] Telbivudine was given to 135 HBV-positive, HIV-negative women during the third trimester and was well tolerated, and perinatal transmission of HBV was lower in telbivudine-treated mothers (0% vs. 8%; P = 0.002).[14, 17] Each of these anti-HBV drugs should be administered only in addition to a fully suppressive regimen for HIV. Because these other anti-HBV drugs also have weak activity against HIV, they may select for anti-HIV drug resistance in the

absence of a fully suppressive ARV regimen as well as potential cross resistance to other ARV drugs. (Entecavir, for example, can select for the M184V mutation, which confers HIV resistance to lamivudine and emtricitabine.) These drugs should be used during pregnancy only if the preferred drugs are not appropriate in specific cases. Cases of exposure during pregnancy to any of the ARV drugs and HBV drugs listed should be reported to the Antiretroviral Pregnancy Registry (800-258-4263; http://www.apregistry.com).

Interferon alfa and pegylated interferon alfa are not recommended for use in pregnancy and should be used only if the potential benefits outweigh the potential risks. Although interferons are not teratogenic, they are abortifacient at high doses in monkeys and should not be used in pregnant women because of the direct antigrowth and antiproliferative effects of these agents.[18]

Following initiation of ARV drugs, an elevation in hepatic enzymes can occur in HIV/HBV-coinfected women—particularly those with low CD-cell counts at the time of treatment initiation—as a result of an immune-mediated flare in HBV disease triggered by immune reconstitution with effective HIV therapy. HBV infection also can increase hepatotoxic risk of certain ARV drugs, specifically protease inhibitors and nevirapine. Pregnant women with HIV/HBV coinfection should be counseled about signs and symptoms of liver toxicity, and transaminases should be assessed 1 month following initiation of ARV drugs and at least every 3 months thereafter. If hepatic toxicity occurs, it may be necessary to consider substituting a less hepatotoxic regimen or, if clinical symptoms or significant elevations of transaminases occur, drugs may need to be temporarily discontinued. Differentiating between a flare in HBV disease due to immune reconstitution and drug toxicity often can be difficult, and consultation with an expert in HIV and HBV coinfection is strongly recommended. Because tenofovir has potential to cause renal toxicity, kidney function also should be monitored regularly in women receiving this drug, based on toxicity seen in non-pregnant adults.

Following delivery, considerations regarding continuation of the ARV drug regimen are the same as for other non-pregnant individuals (see General Principles Regarding Use of Antiretroviral Drugs During Pregnancy). Discontinuation of agents with anti-HBV activity may be associated with hepatocellular damage resulting from reactivation of HBV. Frequent monitoring of liver function tests for potential HBV flare is recommended in women with HIV/HBV coinfection whose ARV drugs are discontinued postpartum, with prompt reinitiation of treatment for both HIV and HBV if a flare is suspected.

Within 12 hours of birth, all infants who weigh >2,000 g born to mothers with chronic HBV infection should receive HBIG and the first dose of the HBV vaccination series. The second and third doses of vaccine should be administered at ages 1 and 6 months, respectively. This regimen is >95% effective in preventing HBV infection in these infants. Consult the CDC MMWR recommendations for similar infants with birth weights <2,000 g at birth.[19]

## References


1. Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents. Department of Health and Human Services. Available at http://aidsinfo.nih.gov/contentfiles/lvguidelines/AdultandAdolescentGL.pdf. Accessed June 19, 2012.
2. Kaplan JE, Benson C, Holmes KH, et al. Guidelines for prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from CDC, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. *MMWR Recomm Rep*. Apr 10 2009;58(RR-4):1-207; quiz CE201-204. Available at http://www.ncbi.nlm.nih.gov/pubmed/19357635.
3. Centers for Disease Control and Prevention. Guidelines for Vaccinating Pregnant Women, Hepatitis A. Updated December 20, 2011. Available at (http://www.cdc.gov/vaccines/pubs/preg-guide.htm#hepa)
4. Grob P, Jilg W, Bornhak H, et al. Serological pattern "anti-HBc alone": report on a workshop. *J Med Virol*. Dec 2000;62(4):450-455. Available at http://www.ncbi.nlm.nih.gov/pubmed/11074473.

5. Hofer M, Joller-Jemelka HI, Grob PJ, Luthy R, Opravil M. Frequent chronic hepatitis B virus infection in HIV-infected patients positive for antibody to hepatitis B core antigen only. Swiss HIV Cohort Study. *Eur J Clin Microbiol Infect Dis*. Jan 1998;17(1):6-13. Available at http://www.ncbi.nlm.nih.gov/pubmed/9512175.

6. Silva AE, McMahon BJ, Parkinson AJ, Sjogren MH, Hoofnagle JH, Di Bisceglie AM. Hepatitis B virus DNA in persons with isolated antibody to hepatitis B core antigen who subsequently received hepatitis B vaccine. *Clin Infect Dis*. Apr 1998;26(4):895-897. Available at http://www.ncbi.nlm.nih.gov/pubmed/9564471.

7. Lok AS, Lai CL, Wu PC. Prevalence of isolated antibody to hepatitis B core antigen in an area endemic for hepatitis B virus infection: implications in hepatitis B vaccination programs. *Hepatology*. Jul-Aug 1988;8(4):766-770. Available at http://www.ncbi.nlm.nih.gov/pubmed/2968945.

8. del Canho R, Grosheide PM, Schalm SW, de Vries RR, Heijtink RA. Failure of neonatal hepatitis B vaccination: the role of HBV-DNA levels in hepatitis B carrier mothers and HLA antigens in neonates. *J Hepatol*. Apr 1994;20(4):483-486. Available at http://www.ncbi.nlm.nih.gov/pubmed/8051386.

9. Ngui SL, Andrews NJ, Underhill GS, Heptonstall J, Teo CG. Failed postnatal immunoprophylaxis for hepatitis B: characteristics of maternal hepatitis B virus as risk factors. *Clin Infect Dis*. Jul 1998;27(1):100-106. Available at http://www.ncbi.nlm.nih.gov/pubmed/9675462.

10. Wiseman E, Fraser MA, Holden S, et al. Perinatal transmission of hepatitis B virus: an Australian experience. *Med J Aust*. May 4 2009;190(9):489-492. Available at http://www.ncbi.nlm.nih.gov/pubmed/19413519.

11. van Nunen AB, de Man RA, Heijtink RA, Niesters HG, Schalm SW. Lamivudine in the last 4 weeks of pregnancy to prevent perinatal transmission in highly viremic chronic hepatitis B patients. *J Hepatol*. Jun 2000;32(6):1040-1041. Available at http://www.ncbi.nlm.nih.gov/pubmed/10898328.

12. van Zonneveld M, van Nunen AB, Niesters HG, de Man RA, Schalm SW, Janssen HL. Lamivudine treatment during pregnancy to prevent perinatal transmission of hepatitis B virus infection. *J Viral Hepat*. Jul 2003;10(4):294-297. Available at http://www.ncbi.nlm.nih.gov/pubmed/12823596.

13. Shi Z, Yang Y, Ma L, Li X, Schreiber A. Lamivudine in late pregnancy to interrupt in utero transmission of hepatitis B virus: a systematic review and meta-analysis. *Obstet Gynecol*. Jul 2010;116(1):147-159. Available at http://www.ncbi.nlm.nih.gov/pubmed/20567182.

14. Pan CQ, Han GR, Jiang HX, et al. Telbivudine prevents vertical transmission from HBeAg-positive women with chronic hepatitis B. *Clin Gastroenterol Hepatol*. 2012 May;10(5):520-6. Available at: http://www.ncbi.nlm.nih.gov/pubmed/22343511.

15. Kazim SN, Wakil SM, Khan LA, Hasnain SE, Sarin SK. Vertical transmission of hepatitis B virus despite maternal lamivudine therapy. *Lancet*. Apr 27 2002;359(9316):1488-1489. Available at http://www.ncbi.nlm.nih.gov/pubmed/11988251.

16. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.

17. Han GR, Cao MK, Zhao W, et al. A prospective and open-label study for the efficacy and safety of telbivudine in pregnancy for the prevention of perinatal transmission of hepatitis B virus infection. *J Hepatol*. Dec 2011;55(6):1215-1221. Available at http://www.ncbi.nlm.nih.gov/pubmed/21703206.

18. Boskovic R, Wide R, Wolpin J, Bauer DJ, Koren G. The reproductive effects of beta interferon therapy in pregnancy: a longitudinal cohort. *Neurology*. Sep 27 2005;65(6):807-811. Available at http://www.ncbi.nlm.nih.gov/pubmed/16186517.

19. Mast EE, Margolis HS, Fiore AE, et al. A comprehensive immunization strategy to eliminate transmission of hepatitis B virus infection in the United States: recommendations of the Advisory Committee on Immunization Practices (ACIP) part 1: immunization of infants, children, and adolescents. *MMWR Recomm Rep*. Dec 23 2005;54(RR-16):1-31. Available at http://www.ncbi.nlm.nih.gov/pubmed/16371945.

## Special Situations — HIV/Hepatitis C Virus Coinfection (Last updated July 31, 2012; last reviewed July 31, 2012)

### Panel's Recommendations

- Screening for hepatitis C virus (HCV) infection is recommended for all HIV-infected pregnant women who have not been screened during the current pregnancy **(AIII)**.
- Interferon alfa and pegylated interferon alfa are not recommended and ribavirin is contraindicated during pregnancy **(AIII)**.
- Recommendations for antiretroviral (ARV) drug use during pregnancy are the same for women who have chronic HCV as for those without HCV coinfection **(BIII)**.
- Pregnant women with HIV/HCV coinfection receiving ARV drugs should be counseled about signs and symptoms of liver toxicity, and transaminases should be assessed 1 month following initiation of ARV drugs and then every 3 months thereafter **(BIII)**.
- Decisions concerning mode of delivery in HIV/HCV-coinfected pregnant women should be based on standard obstetric and HIV-related indications alone (see Intrapartum Care) **(BIII)**.
- Infants born to women with HIV/HCV coinfection should be evaluated for HCV infection with anti-HCV antibody testing after age 18 months **(AII)**. Infants who test positive for anti-HCV antibodies should undergo confirmatory HCV RNA testing. If earlier diagnosis is indicated or desired, HCV RNA virologic testing can be performed between ages 3 and 6 months **(AIII)**.
- Women who are found to have chronic HCV infection should also be screened for hepatitis A virus (HAV) and hepatitis B virus (HBV) because they are at increased risk of complications from those two infections. Women with chronic HCV who are negative for hepatitis A immunoglobulin G should receive the HAV vaccine series **(AIII)**. If they are not infected with HBV (that is, hepatitis B surface antigen negative, hepatitis B core antibody negative, and hepatitis B surface antibody negative), they should receive the HBV vaccine series **(AIII)**.

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***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*

***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion*

For additional information on hepatitis C and HIV, see *Hepatitis C Virus Infection* of the *Guidelines for Prevention and Treatment of Opportunistic Infections in HIV-infected Adults and Adolescents, Recommendations from the Centers for Disease Control and Prevention (CDC), the National Institutes of Health (NIH), and the HIV Medicine Association of the Infectious Diseases Society of America* at *http://www.cdc.gov/mmwr/pdf/rr/rr5804.pdf*.[1]

Coinfection with hepatitis C virus (HCV) is not uncommon in HIV-infected women, particularly those infected via parenteral use of drugs; among HIV-infected pregnant women, the HCV seroprevalence rate ranges from 17% to 54%.[2] Screening for chronic HCV infection using a sensitive immunoassay for HCV antibody is recommended for all HIV-infected individuals, including pregnant women. False-negative anti-HCV immunoassay results can occur in HIV-infected individuals, particularly those with very low CD4 T-lymphocyte (CD4-cell) counts, but it is uncommon with the most sensitive immunoassays. Individuals who have a positive HCV antibody test should undergo confirmatory testing for plasma HCV RNA using a commercially available quantitative diagnostic assay. Testing for HCV RNA also should be performed on individuals whose serologic test results are indeterminate or negative but in whom HCV infection is suspected because of elevated aminotransaminase levels or risk factors such as a history of intravenous drug use.

Few data exist on the optimal management of HIV-infected pregnant women with HCV coinfection. Recommendations for antiretroviral (ARV) drug use during pregnancy for treatment of HIV and/or prevention of mother-to-child transmission (MTCT) are the same for women who have HCV coinfection as for those with HIV alone (see HIV/Hepatitis C [HCV] Coinfection in Guidelines for the Use of Antiretroviral Agents in HIV-1-Infected Adults and Adolescents, http://AIDSinfo.nih.gov). However, currently available anti-HCV treatments are not recommended during pregnancy. Interferons are not recommended for use in pregnancy because they are abortifacient at high doses in monkeys and have direct antigrowth and antiproliferative effects,[3] and ribavirin is contraindicated (Food and Drug Administration [FDA] Pregnancy Category X) because of teratogenicity at low doses in multiple animal species. Ribavirin-associated defects in animals include limb abnormalities, craniofacial defects, anencephaly, and anophthalmia. Concerns have been raised about potential mutagenic effects of ribavirin in the offspring of men taking ribavirin before conception because of possible accumulation of ribavirin in spermatozoa. However, in a small number of inadvertent pregnancies occurring in partners of men receiving ribavirin therapy, no adverse outcomes were reported.[4] Pregnancies that occur in women taking ribavirin should be reported to the Ribavirin Pregnancy Registry (800-593-2214 or http://www.ribavirinpregnancyregistry.com). There are no data in pregnancy on telaprevir or boceprevir, both recently approved by the FDA for treatment of HCV. Telaprevir and boceprevir are Pregnancy Category B agents; however, these agents must be used in combination with pegylated inteferon and ribavirin, which should not be used in pregnancy. In addition, recent data demonstrated potential drug interactions between boceprevir and certain ritonavir-boosted protease inhibitor (PI) regimens that may reduce the effectiveness of these medications if used together (for more detailed information see Guidelines for the Use of Antiretroviral Agents in HIV-1-Infected Adults and Adolescents).[5] Pregnancy does not appear to influence the course of HCV infection and women with chronic HCV generally do quite well during pregnancy, provided that their infections have not progressed to decompensated cirrhosis.[6]

Because of the added risk of acute infection with hepatitis A virus (HAV) and hepatitis B virus (HBV) in individuals with chronic HCV, women who are found to have chronic HCV infection should also be screened for HAV and HBV. Women with chronic HCV infection who are hepatitis A immunoglobulin G negative should receive the HAV vaccine series, and if they are not infected with HBV (that is, hepatitis B surface antigen negative, hepatitis B core antibody negative, and hepatitis B surface antibody negative), they should receive the HBV vaccine series.

In a majority of studies, the incidence of HCV transmission from mother to infant increases if the mother is coinfected with HIV, with transmission rates between 10% and 20%.[7-10] These higher transmission rates are likely related to an increase in HCV viremia and/or other HIV-related impact on HCV disease activity.[11] A European study of perinatal transmission of HCV found that use of effective combination therapy for HIV was associated with a strong trend toward reduction in HCV transmission (odds ratio 0.26, 95% confidence interval, 0.07–1.01).[12] Maternal HIV/HCV coinfection also may increase the risk of perinatal transmission of HIV.[13] Therefore, potent antiretroviral therapy (ART) with at least three drugs is recommended for all HIV/HCV-coinfected pregnant women, regardless of CD4-cell count or HIV viral load.

As with chronic HBV infection, an elevation in hepatic enzymes following initiation of ART can occur in HIV/HCV-coinfected women—particularly in those with low CD4-cell counts at treatment initiation—as a result of an immune-mediated flare in HCV disease triggered by immune reconstitution with effective ART. Like HBV, HCV infection may increase the hepatotoxic risk of certain ARV agents, specifically PIs and nevirapine. Pregnant women with HIV/HCV coinfection should be counseled about signs and symptoms of liver toxicity, and transaminase levels should be assessed 1 month after initiation of ARV drugs and then every 3 months thereafter. If hepatic toxicity occurs, consideration may need to be given to substituting a less hepatotoxic drug regimen, and if clinical symptoms or significant elevations of transaminases occur, drugs may need to be temporarily discontinued. Differentiating between a flare in HCV disease associated with

immune reconstitution and drug toxicity often can be difficult; therefore, consultation with an expert in HIV and HCV coinfection is strongly recommended.

As with transmission of HIV, risk of MTCT of HCV may be increased by use of internal fetal monitoring, amniocentesis, and rupture of membranes for more than 6 hours.[9, 14] The majority of studies of elective cesarean delivery that have included HIV-infected women have found that the procedure does not reduce the risk of perinatal transmission of HCV.[12, 15-17] The general recommendations for intrapartum management are the same in women with HIV/HCV coinfection as in those with HIV infection alone (see Intrapartum Care).

Infants born to women with HIV/HCV coinfection should be assessed for HCV infection with anti-HCV antibody testing after age 18 months. Infants who screen positive should undergo confirmatory HCV RNA testing. HCV RNA virologic testing can be done between ages 3 and 6 months, if earlier diagnosis is indicated or desirable.[18, 19] Because HCV viremia can be intermittent, at least two negative tests are needed to exclude HCV infection. Children are considered to be HCV infected if they have two or more positive HCV RNA polymerase chain reaction results or are HCV antibody positive beyond age 18 months.

## References


1. Kaplan JE, Benson C, Holmes KH, et al. Guidelines for prevention and treatment of opportunistic infections in HIV-infected adults and adolescents: recommendations from CDC, the National Institutes of Health, and the HIV Medicine Association of the Infectious Diseases Society of America. *MMWR Recomm Rep*. Apr 10 2009;58(RR-4):1-207; quiz CE201-204. Available at http://www.ncbi.nlm.nih.gov/pubmed/19357635.
2. Thomas SL, Newell ML, Peckham CS, Ades AE, Hall AJ. A review of hepatitis C virus (HCV) vertical transmission: risks of transmission to infants born to mothers with and without HCV viraemia or human immunodeficiency virus infection. *Int J Epidemiol*. Feb 1998;27(1):108-117. Available at http://www.ncbi.nlm.nih.gov/pubmed/9563703.
3. Boskovic R, Wide R, Wolpin J, Bauer DJ, Koren G. The reproductive effects of beta interferon therapy in pregnancy: a longitudinal cohort. *Neurology*. Sep 27 2005;65(6):807-811. Available at http://www.ncbi.nlm.nih.gov/pubmed/16186517.
4. Hegenbarth K, Maurer U, Kroisel PM, Fickert P, Trauner M, Stauber RE. No evidence for mutagenic effects of ribavirin: report of two normal pregnancies. *The American journal of gastroenterology*. Jul 2001;96(7):2286-2287. Available at http://www.ncbi.nlm.nih.gov/pubmed/11467687.
5. U.S. Food and Drug Administration. Victrelis (boceprevir) and Ritonavir-Boosted HIV Protease Inhibitor Drugs - Drug Interactions. Available at http://www.fda.gov/ForConsumers/ByAudience/ForPatientAdvocates/ucm291389.htm. Posted 2/10/2012, accessed March 12, 2012.
6. Sookoian S. Effect of pregnancy on pre-existing liver disease: chronic viral hepatitis. *Ann Hepatol*. Jul-Sep 2006;5(3):190-197. Available at http://www.ncbi.nlm.nih.gov/pubmed/17060881.
7. Tovo PA, Palomba E, Ferraris G, et al. Increased risk of maternal-infant hepatitis C virus transmission for women coinfected with human immunodeficiency virus type 1. Italian Study Group for HCV Infection in Children. *Clin Infect Dis*. Nov 1997;25(5):1121-1124. Available at http://www.ncbi.nlm.nih.gov/pubmed/9402369.
8. Gibb DM, Goodall RL, Dunn DT, et al. Mother-to-child transmission of hepatitis C virus: evidence for preventable peripartum transmission. *Lancet*. Sep 9 2000;356(9233):904-907. Available at http://www.ncbi.nlm.nih.gov/pubmed/11036896.
9. Mast EE, Hwang LY, Seto DS, et al. Risk factors for perinatal transmission of hepatitis C virus (HCV) and the natural history of HCV infection acquired in infancy. *J Infect Dis*. Dec 1 2005;192(11):1880-1889. Available at http://www.ncbi.nlm.nih.gov/pubmed/16267758.
10. Alter MJ. Epidemiology of viral hepatitis and HIV co-infection. *J Hepatol*. 2006;44(1 Suppl):S6-9. Available at http://www.ncbi.nlm.nih.gov/pubmed/16352363.

11. Polis CB, Shah SN, Johnson KE, Gupta A. Impact of maternal HIV coinfection on the vertical transmission of hepatitis C virus: a meta-analysis. *Clin Infect Dis*. Apr 15 2007;44(8):1123-1131. Available at http://www.ncbi.nlm.nih.gov/pubmed/17366462.

12. European Paediatric Hepatitis C Virus Network. A significant sex--but not elective cesarean section--effect on mother-to-child transmission of hepatitis C virus infection. *J Infect Dis*. Dec 1 2005;192(11):1872-1879. Available at http://www.ncbi.nlm.nih.gov/pubmed/16267757.

13. Hershow RC, Riester KA, Lew J, et al. Increased vertical transmission of human immunodeficiency virus from hepatitis C virus-coinfected mothers. Women and Infants Transmission Study. *J Infect Dis*. Aug 1997;176(2):414-420. Available at http://www.ncbi.nlm.nih.gov/pubmed/9237706.

14. Valladares G, Chacaltana A, Sjogren MH. The management of HCV-infected pregnant women. *Ann Hepatol*. 2010;9(Suppl):92-97. Available at http://www.ncbi.nlm.nih.gov/pubmed/20714003.

15. Ghamar Chehreh ME, Tabatabaei SV, Khazanehdari S, Alavian SM. Effect of cesarean section on the risk of perinatal transmission of hepatitis C virus from HCV-RNA+/HIV- mothers: a meta-analysis. *Arch Gynecol Obstet*. Feb 2011;283(2):255-260. Available at http://www.ncbi.nlm.nih.gov/pubmed/20652289.

16. Marine-Barjoan E, Berrebi A, Giordanengo V, et al. HCV/HIV co-infection, HCV viral load and mode of delivery: risk factors for mother-to-child transmission of hepatitis C virus? *AIDS*. Aug 20 2007;21(13):1811-1815. Available at http://www.ncbi.nlm.nih.gov/pubmed/17690581.

17. McMenamin MB, Jackson AD, Lambert J, et al. Obstetric management of hepatitis C-positive mothers: analysis of vertical transmission in 559 mother-infant pairs. *Am J Obstet Gynecol*. Sep 2008;199(3):315 e311-315. Available at http://www.ncbi.nlm.nih.gov/pubmed/18771997.

18. Indolfi G, Resti M. Perinatal transmission of hepatitis C virus infection. *J Med Virol*. May 2009;81(5):836-843. Available at http://www.ncbi.nlm.nih.gov/pubmed/19319981.

19. Polywka S, Pembrey L, Tovo PA, Newell ML. Accuracy of HCV-RNA PCR tests for diagnosis or exclusion of vertically acquired HCV infection. *J Med Virol*. Feb 2006;78(2):305-310. Available at http://www.ncbi.nlm.nih.gov/pubmed/16372293.

## Special Situations — HIV-2 Infection and Pregnancy (Last updated July 31, 2012; last reviewed July 31, 2012)

### Panel's Recommendations

- HIV-2 infection should be suspected in pregnant women who are from—or have partners from—countries in which the disease is endemic, who are HIV antibody positive on an initial enzyme-linked immunoassay screening test, and who have repeatedly indeterminate results on HIV-1 Western blot along with HIV-1 RNA viral loads at or below the limit of detection **(BII)**.
- A regimen with two nucleoside reverse transcriptase inhibitors (NRTIs) and a boosted protease inhibitor (PI) currently is recommended for HIV-2-infected pregnant women who require treatment for their own health because they have significant clinical disease or CD4 T-lymphocyte (CD4-cell) counts <500 cells/mm$^3$ **(AIII)**.
  - Based on available data on safety in pregnancy, zidovudine/lamivudine plus lopinavir/ritonavir would be preferred **(AIII)**. Tenofovir plus lamivudine or emtricitabine plus lopinavir/ritonavir can be considered as an alternative **(BIII)**.
- Optimal prophylactic regimens have not been defined for HIV-2-infected pregnant women who do not require treatment for their own health (that is, CD4-cell counts >500 cells/mm$^3$ and no significant clinical disease). Experts have recommended the following approaches:
  - A boosted PI-based regimen (two NRTIs plus lopinavir/ritonavir) for prophylaxis, with the drugs stopped postpartum **(BIII)**; or
  - Zidovudine prophylaxis alone during pregnancy and intrapartum **(BIII)**.
- Non-nucleoside reverse transcriptase inhibitors and enfuvirtide are not active against HIV-2 and should not be used for treatment or prophylaxis **(AIII)**.
- All infants born to HIV-2-infected mothers should receive the standard 6-week zidovudine prophylactic regimen **(BIII)**.
- In the United States, breastfeeding is not recommended for infants of HIV-2-infected mothers **(AIII)**.

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***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*

***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion*

HIV-2 infection is endemic in West African countries including Ivory Coast, Ghana, Cape Verde, Gambia, Mali, Senegal, Liberia, Guinea, Burkina Faso, Nigeria, Mauritania, Sierra Leone, Guinea Bissau, Niger, Sao Tome, and Togo; Angola; Mozambique; and in parts of India.[1-3] It also occurs in countries such as France and Portugal, which have large numbers of immigrants from these regions.[3, 4] HIV-2 is rare in the United States. Between 1998 and 2010, a total of 242 HIV-2 cases were reported to the Centers for Disease Control and Prevention (CDC), with 166 cases meeting criteria for HIV-2 diagnosis. These 166 cases constituted only 0.01% of the more than 1.4 million U.S. cases of HIV infection.[5] Of the 50 women aged 15 to 44 years at diagnosis, 24 (48%) were pregnant at or after HIV-2 diagnosis.[5] HIV-2 infection should be suspected in pregnant women who are from—or who have partners from—countries in which the disease is endemic, who are HIV-1 antibody positive on an initial enzyme-linked immunoassay screening test, and who have repeatedly indeterminate results on HIV-1 Western blot along with HIV-1 RNA viral loads at or below the limit of detection.[6, 7] This pattern of HIV testing can also be seen in patients who have a false-positive HIV-1 test.

Although most commercially available HIV screening tests can detect both HIV-1 and HIV-2, they do not distinguish between the two viruses. The Bio-Rad Laboratories Multispot HIV-1/HIV-2 test is the only antibody test that can distinguish between HIV-1 and HIV-2 that is approved by the Food and Drug

Administration (FDA) and should be used if HIV-2 is suspected. In some commercial and public health laboratories, HIV-2 supplemental tests, such as HIV-2 immunoblot or HIV-2-specific Western blot, are available. However, none of these tests has been FDA approved for diagnosis or clinical management of HIV-2. HIV-2 viral load assays available in the United States are not FDA approved and hence cannot be recommended for clinical use. All HIV-2 cases should be reported to the HIV surveillance program of the state or local health department, which can arrange for additional confirmatory testing for HIV-2 by the CDC.

HIV-2 has a longer asymptomatic phase than HIV-1, with a slower progression to AIDS. The most common mode of HIV-2 transmission is through heterosexual sex. HIV-2 is less infectious than HIV-1, with a 5-fold lower rate of sexual transmission and 20- to 30-fold lower rate of vertical transmission.[3, 8, 9] Several studies confirm that rates of mother-to-child transmission (MTCT) of HIV-2 are low with and without interventions (0%–4%), which may be a result of reduced plasma viral loads and less cervical viral shedding, compared with that seen in HIV-1-infected women.[10-13] HIV-2 also can be transmitted through breastfeeding. HIV-2 infection does not protect against HIV-1 and dual infection, which carries the same prognosis as HIV-1 monoinfection, can occur.

Few data exist on which to base treatment decisions or strategies for prevention of mother-to-child transmission (PMTCT) in patients infected with HIV-2. Non-nucleoside reverse transcriptase inhibitors (NNRTIs) and enfuvirtide are not active against HIV-2 and should not be used for treatment or prophylaxis.[14, 15] HIV-2 has variable sensitivity to protease inhibitors (PIs), with lopinavir, saquinavir, and darunavir having the most activity against the virus.[16] The integrase inhibitors raltegravir and elvitegravir also appear to be effective against HIV-2.[3, 17, 18]

The care of HIV-2-infected pregnant women has been based on expert opinion. A regimen with two nucleoside reverse transcriptase inhibitors and a boosted PI currently is recommended for HIV-2-infected pregnant women who require treatment for their own health because they have significant clinical disease or CD4-cell counts <500 cells/mm$^3$.[19] Based on available data on safety in pregnancy, zidovudine/lamivudine plus lopinavir/ritonavir would be preferred. Tenofovir plus lamivudine or emtricitabine plus lopinavir/ritonavir can be considered as an alternative.[20, 21] NNRTIs should not be used because they are not active against HIV-2. All infants born to mothers infected with HIV-2 should receive the standard 6-week zidovudine prophylactic regimen.

For HIV-2-infected pregnant women with CD4-cell counts >500 cells/mm$^3$ and no significant clinical disease, who do not require treatment for their own health, some experts would use a boosted PI-based regimen for prophylaxis and stop the drugs postpartum. Other experts would consider zidovudine prophylaxis alone during pregnancy and intrapartum.[11] Because HIV-2 has a significantly lower risk of MTCT than does HIV-1, single-drug prophylaxis with zidovudine alone can be considered for PMTCT. All infants born to mothers infected with HIV-2 should receive the standard 6-week zidovudine prophylactic regimen.[21] The possible risks and benefits of antiretroviral (ARV) prophylaxis should be discussed with the mothers.

Pregnant women who have HIV-1/HIV-2 coinfection should be treated according to the guidelines for HIV-1-monoinfected patients, making sure that the ARV regimen chosen is also appropriate for HIV-2.

Other than the standard obstetrical indications, no data exist regarding the role of elective cesarean delivery in women who are infected with HIV-2. The risk to infants from breastfeeding is lower for HIV-2 than for HIV-1, but breastfeeding should be avoided in the United States and other resource-rich countries where safe infant formula is readily available.[11]

Infants born to HIV-2-infected mothers should be tested for HIV-2 infection with HIV-2-specific virologic assays at time points similar to those used for HIV-1 testing.[22] HIV-2 virologic assays are not commercially available, but the National Perinatal HIV Hotline (1-888-448-8765) can provide a list of sites that perform this testing.

Testing of infants at age 18 months (for example, with the Bio-Rad Laboratories Multispot HIV-1/HIV-2 test) also is recommended to confirm clearance of HIV-2 antibodies.[21]

## References


1. De Cock KM, Brun-Vezinet F. Epidemiology of HIV-2 infection. *AIDS*. 1989;3(Suppl 1):S89-95. Available at http://www.ncbi.nlm.nih.gov/pubmed/2514761.
2. De Cock KM, Adjorlolo G, Ekpini E, et al. Epidemiology and transmission of HIV-2. Why there is no HIV-2 pandemic. *JAMA*. Nov 3 1993;270(17):2083-2086. Available at http://www.ncbi.nlm.nih.gov/pubmed/8147962.
3. Campbell-Yesufu OT, Gandhi RT. Update on human immunodeficiency virus (HIV)-2 infection. *Clin Infect Dis*. Mar 15 2011;52(6):780-787. Available at http://www.ncbi.nlm.nih.gov/pubmed/21367732.
4. Barin F, Cazein F, Lot F, et al. Prevalence of HIV-2 and HIV-1 Group O infections among new HIV diagnoses in France: 2003-2006. *AIDS* 2007 Nov 12;21 (17):2351-53. Available at http://www.ncbi.nlm.nih.gov/pubmed/18090288.
5. Centers for Disease Control and Prevention. HIV-2 Infection Surveillance--United States, 1987-2009. *MMWR Morb Mortal Wkly Rep*. Jul 29 2011;60(29):985-988. Available at http://www.ncbi.nlm.nih.gov/pubmed/21796096.
6. O'Brien TR, George JR, Epstein JS, Holmberg SD, Schochetman G. Testing for antibodies to human immunodeficiency virus type 2 in the United States. *MMWR Recomm Rep*. Jul 17 1992;41(RR-12):1-9. Available at http://www.ncbi.nlm.nih.gov/pubmed/1324395.
7. Torian LV, Eavey JJ, Punsalang AP, et al. HIV type 2 in New York City, 2000-2008. *Clin Infect Dis*. Dec 1 2010;51(11):1334-1342. Available at http://www.ncbi.nlm.nih.gov/pubmed/21039219.
8. Kanki PJ, Travers KU, S MB, et al. Slower heterosexual spread of HIV-2 than HIV-1. *Lancet*. Apr 16 1994;343(8903):943-946. Available at http://www.ncbi.nlm.nih.gov/pubmed/7909009.
9. Matheron S, Courpotin C, Simon F, et al. Vertical transmission of HIV-2. *Lancet*. May 5 1990;335(8697):1103-1104. Available at http://www.ncbi.nlm.nih.gov/pubmed/1970407.
10. O'Donovan D, Ariyoshi K, Milligan P, et al. Maternal plasma viral RNA levels determine marked differences in mother-to-child transmission rates of HIV-1 and HIV-2 in The Gambia. MRC/Gambia Government/University College London Medical School working group on mother-child transmission of HIV. *AIDS*. Mar 10 2000;14(4):441-448. Available at http://www.ncbi.nlm.nih.gov/pubmed/10770548.
11. Burgard M, Jasseron C, Matheron S, et al. Mother-to-child transmission of HIV-2 infection from 1986 to 2007 in the ANRS French Perinatal Cohort EPF-CO1. *Clin Infect Dis*. Oct 1 2010;51(7):833-843. Available at http://www.ncbi.nlm.nih.gov/pubmed/20804413.
12. Adjorlolo-Johnson G, De Cock KM, Ekpini E, et al. Prospective comparison of mother-to-child transmission of HIV-1 and HIV-2 in Abidjan, Ivory Coast. *JAMA*. Aug 10 1994;272(6):462-466. Available at http://www.ncbi.nlm.nih.gov/pubmed/8040982.
13. Andreasson PA, Dias F, Naucler A, Andersson S, Biberfeld G. A prospective study of vertical transmission of HIV-2 in Bissau, Guinea-Bissau. *AIDS*. Jul 1993;7(7):989-993. Available at http://www.ncbi.nlm.nih.gov/pubmed/8357558.
14. Tuaillon E, Gueudin M, Lemee V, et al. Phenotypic susceptibility to nonnucleoside inhibitors of virion-associated reverse transcriptase from different HIV types and groups. *J Acquir Immune Defic Syndr*. Dec 15 2004;37(5):1543-1549. Available at http://www.ncbi.nlm.nih.gov/pubmed/15577405.
15. Poveda E, Rodes B, Toro C, Soriano V. Are fusion inhibitors active against all HIV variants? *AIDS Res Hum Retroviruses*. Mar 2004;20(3):347-348. Available at http://www.ncbi.nlm.nih.gov/pubmed/15117459.
16. Desbois D, Roquebert B, Peytavin G, et al. In vitro phenotypic susceptibility of human immunodeficiency virus type 2 clinical isolates to protease inhibitors. *Antimicrob Agents Chemother*. Apr 2008;52(4):1545-1548. Available at http://www.ncbi.nlm.nih.gov/pubmed/18227188.

17. Roquebert B, Damond F, Collin G, et al. HIV-2 integrase gene polymorphism and phenotypic susceptibility of HIV-2 clinical isolates to the integrase inhibitors raltegravir and elvitegravir in vitro. *J Antimicrob Chemother*. Nov 2008;62(5):914-920. Available at http://www.ncbi.nlm.nih.gov/pubmed/18718922.

18. Bercoff DP, Triqueneaux P, Lambert C, et al. Polymorphisms of HIV-2 integrase and selection of resistance to raltegravir. *Retrovirology*. 2010;7:98. Available at http://www.ncbi.nlm.nih.gov/pubmed/21114823.

19. Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents. Department of Health and Human Services. Available at http://aidsinfo.nih.gov/contentfiles/lvguidelines/AdultandAdolescentGL.pdf. Accessed June 19, 2012.

20. Gilleece Y, Chadwick DR, Breuer J, et al. British HIV Association guidelines for antiretroviral treatment of HIV-2-positive individuals 2010. *HIV Med*. Nov 2010;11(10):611-619. Available at http://www.ncbi.nlm.nih.gov/pubmed/20961377.

21. de Ruiter A, Mercey D, Anderson J, et al. British HIV Association and Children's HIV Association guidelines for the management of HIV infection in pregnant women 2008. *HIV Med*. Aug 2008;9(7):452-502. Available at http://www.ncbi.nlm.nih.gov/pubmed/18840151.

22. Panel on Antiretroviral Therapy and Medical Management of HIV-Infected Children. Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection. Available at http://aidsinfo.nih.gov/contentfiles/lvguidelines/PediatricGuidelines.pdf. Accessed June 19, 2012.

## Special Situations — Acute HIV Infection (Last updated July 31, 2012; last reviewed July 31, 2012)

### Panel's Recommendations

- When acute retroviral syndrome is suspected in pregnancy or during breastfeeding, a plasma HIV RNA test should be obtained in conjunction with an HIV antibody test (see Identifying, Diagnosing, and Managing Acute HIV-1 Infection in the Guidelines for the Use of Antiretroviral Agents in HIV-1-Infected Adults and Adolescents) **(AII)**.
- Repeat HIV antibody testing in the third trimester is recommended for pregnant women with initial negative HIV antibody tests who are known to be at risk of HIV, are receiving care in facilities that have an HIV incidence in pregnant women of at least 1 per 1,000 per year, are incarcerated, or who reside in jurisdictions with elevated HIV incidence (see Revised Recommendations for HIV Testing of Adults, Adolescents, and Pregnant Women in Health-Care Settings) **(AII)**.
- All pregnant women with acute or recent HIV infection should start a combination antiretroviral (ARV) drug regimen as soon as possible to prevent mother-to-child transmission, with the goal of suppressing plasma HIV RNA to below detectable levels **(AI)**.
- In women with acute HIV infection, baseline genotypic resistance testing should be performed simultaneously with initiation of the combination ARV regimen, and the ARV regimen should be adjusted, if necessary, to optimize virologic response **(AIII)**.
- Because clinically significant resistance to protease inhibitors (PIs) is less common than resistance to non-nucleoside reverse transcriptase inhibitors in ARV-naive individuals in general, a ritonavir-boosted PI-based regimen should be initiated **(AIII)**.

***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*

***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion*

Primary or acute HIV infection in pregnancy or during breastfeeding is associated with an increased risk of perinatal transmission of HIV and may represent a significant proportion of residual mother-to-child transmission (MTCT) in the United States.

In North Carolina from 2002 to 2005, 5 of 15 women found to have acute HIV infection on nucleic acid amplification testing of pooled HIV antibody-negative specimens were pregnant at the time of testing.[1] All 5 women received antiretroviral (ARV) drugs and delivered HIV-uninfected infants.

From 2002 to 2006, 3,396 HIV-exposed neonates were born in New York State; 22% (9 of 41) of infants born to mothers who acquired HIV during pregnancy became infected with HIV, compared with 1.8% of those born to mothers who did not acquire HIV during pregnancy (odds ratio 15.19; 95% confidence interval, 3.98–56.30). Maternal acquisition of HIV during pregnancy was documented in only 1.3% of perinatal HIV exposures, but it was associated with 9 (13.8%) of the 65 MTCT cases.[2] A case series from China reported a perinatal transmission rate of 35.8% in 106 breastfeeding infants of mothers who acquired HIV postnatally through blood transfusion.[3] The high rate of transmission associated with acute infection likely is related to the combination of the high viral load in plasma, breast milk, and the genital tract associated with acute infection[4, 5] and the fact that the diagnosis is easy to miss, which results in lost opportunities for implementation of prevention interventions.

Health care providers should maintain a high level of suspicion of acute HIV infection in women who are pregnant or breastfeeding and have a compatible clinical syndrome, even when they do not report high-risk behaviors, because it is possible that their sexual partners are practicing high-risk behaviors of which the women are unaware.

An estimated 40%–90% of patients with acute HIV infection will experience symptoms of acute retroviral syndrome, characterized by fever, lymphadenopathy, pharyngitis, skin rash, myalgias/arthralgias, and other symptoms.[4, 6-11] Providers often do not recognize acute HIV infection, however, because the symptoms are similar to those of other common illnesses and individuals with the condition also can be asymptomatic. When acute retroviral syndrome is suspected, a plasma HIV RNA test typically is used in conjunction with an HIV antibody test to diagnose acute infection. A low-positive HIV RNA level (<10,000 copies/mL) may represent a false-positive test because values in acute infection generally are very high (>100,000 copies/mL).[4, 10] In individuals infected with non-B HIV-1 subtypes, however, HIV RNA levels may be lower, even with acute infection, because those subtypes may not amplify as well as subtype B. In that situation, consultation with an HIV treatment specialist is recommended. Confirmatory serologic testing should be performed within 3 months on patients whose acute HIV infection is diagnosed with virologic testing but who are antibody negative or whose antibody levels cannot be determined.

Recent HIV infection also can be detected by repeat HIV antibody testing later in pregnancy in women whose initial HIV antibody testing earlier in pregnancy was negative. A report from the Mother-Infant Rapid Intervention at Delivery study found that 6 (11%) of 54 women whose HIV was identified with rapid HIV testing during labor had primary infection.[12] Repeat HIV testing in the third trimester is recommended for pregnant women known to be at risk of HIV who receive care in facilities with an HIV incidence of at least 1 case per 1,000 pregnant women per year, who are incarcerated, or who reside in jurisdictions with elevated HIV incidence (see Revised Recommendations for HIV Testing of Adults, Adolescents, and Pregnant Women in Health-Care Settings).[13]

Whether treatment of acute or recent HIV infection results in long-term virologic, immunologic, or clinical benefit is unknown, and in non-pregnant adults, therapy currently is considered optional.[14] In pregnant or breastfeeding women, however, acute or recent HIV infection is associated with a high risk of perinatal transmission of HIV. All HIV-infected pregnant women with acute or recent infection should start a combination ARV regimen as soon as possible, with the goal of preventing perinatal transmission by optimal suppression of plasma HIV RNA below detectable levels. Data from the United States and Europe demonstrate that in 6%–16% of patients, transmitted virus may be resistant to at least one ARV drug.[15-17] Therefore, baseline genotypic resistance testing should be performed to guide selection or adjustment of an optimal ARV drug regimen. If results of resistance testing or the source virus's resistance pattern are known, that information should be used to guide selection of the drug regimen, but initiation of the combination ARV regimen should not be delayed. Because clinically significant resistance to protease inhibitors (PIs) is less common than resistance to non-nucleoside reverse transcriptase inhibitors in ARV-naive persons, a PI-based ARV drug regimen generally should be initiated. Choice of regimen should be based on recommendations for use of ARV drugs in pregnancy (see Table 5). Following delivery, considerations regarding continuation of the ARV regimen for treatment are the same for mothers as for other non-pregnant individuals.

When acute HIV infection is diagnosed during pregnancy, and particularly if it is documented in late pregnancy, cesarean delivery is likely to be necessary because there may be insufficient time to fully suppress a patient's viral load. In nursing mothers in whom seroconversion is suspected, breastfeeding should be interrupted and it should not resume if infection is definitively confirmed (see Breastfeeding Infants of Mothers Diagnosed with HIV Infection in Infant Antiretroviral Prophylaxis). In such a situation, consultation with a pediatric HIV specialist regarding appropriate infant management is recommended.

All women who are pregnant or breastfeeding should be counseled about prevention of acquisition of HIV (*Updated U.S. Public Health Service Guidelines for the Management of Occupational Exposures to HIV and Recommendations for Postexposure Prophylaxis* and *Antiretroviral Postexposure Prophylaxis After Sexual, Injection-Drug Use, or Other Nonoccupational Exposure to HIV in the United States*). Several studies suggest that pregnancy may be a time of increased risk of transmission of HIV[18-21], even when controlling for sexual risk behaviors.[18] It is hypothesized that the heightened risk may be attributable to hormonal changes

that affect the genital tract mucosa or immune responses.[18] Although no reliable data on HIV serodiscordance rates in the United States exist, data on women from sub-Saharan Africa show that women in serodiscordant relationships may be particularly vulnerable to acquisition of HIV.[22, 23] HIV testing of the sexual partners of pregnant women should be encouraged. The importance of using condoms should be reinforced in pregnant and breastfeeding women who may be at risk of acquisition of HIV, including those whose partners are HIV infected.

## References


1. Patterson KB, Leone PA, Fiscus SA, et al. Frequent detection of acute HIV infection in pregnant women. *AIDS*. Nov 12 2007;21(17):2303-2308. Available at http://www.ncbi.nlm.nih.gov/pubmed/18090278.
2. Birkhead GS, Pulver WP, Warren BL, Hackel S, Rodriguez D, Smith L. Acquiring human immunodeficiency virus during pregnancy and mother-to-child transmission in New York: 2002-2006. *Obstet Gynecol*. Jun 2010;115(6):1247-1255. Available at http://www.ncbi.nlm.nih.gov/pubmed/20502297.
3. Liang K, Gui X, Zhang YZ, Zhuang K, Meyers K, Ho DD. A case series of 104 women infected with HIV-1 via blood transfusion postnatally: high rate of HIV-1 transmission to infants through breast-feeding. *J Infect Dis*. Sep 1 2009;200(5):682-686. Available at http://www.ncbi.nlm.nih.gov/pubmed/19627245.
4. Hecht FM, Busch MP, Rawal B, et al. Use of laboratory tests and clinical symptoms for identification of primary HIV infection. *AIDS*. May 24 2002;16(8):1119-1129. Available at http://www.ncbi.nlm.nih.gov/pubmed/12004270.
5. Morrison CS, Demers K, Kwok C, et al. Plasma and cervical viral loads among Ugandan and Zimbabwean women during acute and early HIV-1 infection. *AIDS*. Feb 20 2010;24(4):573-582. Available at http://www.ncbi.nlm.nih.gov/pubmed/20154581.
6. Tindall B, Cooper DA. Primary HIV infection: host responses and intervention strategies. *AIDS*. Jan 1991;5(1):1-14. Available at http://www.ncbi.nlm.nih.gov/pubmed/1812848.
7. Niu MT, Stein DS, Schnittman SM. Primary human immunodeficiency virus type 1 infection: review of pathogenesis and early treatment intervention in humans and animal retrovirus infections. *J Infect Dis*. Dec 1993;168(6):1490-1501. Available at http://www.ncbi.nlm.nih.gov/pubmed/8245534.
8. Kinloch-de Loes S, de Saussure P, Saurat JH, Stalder H, Hirschel B, Perrin LH. Symptomatic primary infection due to human immunodeficiency virus type 1: review of 31 cases. *Clin Infect Dis*. Jul 1993;17(1):59-65. Available at http://www.ncbi.nlm.nih.gov/pubmed/8353247.
9. Schacker T, Collier AC, Hughes J, Shea T, Corey L. Clinical and epidemiologic features of primary HIV infection. *Ann Intern Med*. Aug 15 1996;125(4):257-264. Available at http://www.ncbi.nlm.nih.gov/pubmed/8678387.
10. Daar ES, Little S, Pitt J, et al. Diagnosis of primary HIV-1 infection. Los Angeles County Primary HIV Infection Recruitment Network. *Ann Intern Med*. Jan 2 2001;134(1):25-29. Available at http://www.ncbi.nlm.nih.gov/pubmed/11187417.
11. Yerly S, Hirschel B. Diagnosing acute HIV infection. *Expert Rev Anti Infect Ther*. Jan 2012;10(1):31-41. Available at http://www.ncbi.nlm.nih.gov/pubmed/22149612.
12. Nesheim S, Jamieson DJ, Danner SP, et al. Primary human immunodeficiency virus infection during pregnancy detected by repeat testing. *Am J Obstet Gynecol*. Aug 2007;197(2):149 e141-145. Available at http://www.ncbi.nlm.nih.gov/pubmed/17689629.
13. Branson BM, Handsfield HH, Lampe MA, et al. Revised recommendations for HIV testing of adults, adolescents, and pregnant women in health-care settings. *MMWR Recomm Rep*. Sep 22 2006;55(RR-14):1-17; quiz CE11-14. Available at http://www.ncbi.nlm.nih.gov/pubmed/16988643.
14. Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents. Department of Health and Human Services. Available at http://aidsinfo.nih.gov/contentfiles/lvguidelines/AdultandAdolescentGL.pdf. Accessed June 7, 2012

15. Wheeler WH, Ziebell RA, Zabina H, et al. Prevalence of transmitted drug resistance associated mutations and HIV-1 subtypes in new HIV-1 diagnoses, U.S.-2006. *AIDS*. May 15 2010;24(8):1203-1212. Available at http://www.ncbi.nlm.nih.gov/pubmed/20395786.

16. Wheeler WH, Ziebell RA, et al. Prevalence of transmitted drug resistance associated mutations and HIV-1 subtypes in new HIV-1 diagnoses, U.S.-2006. *AIDS*. 2010 May 15;24(8):1203-12. Available at: http://www.ncbi.nlm.nih.gov/pubmed/20395786.

17. Wensing AM, van de Vijver DA, Angarano G, et al. Prevalence of drug-resistant HIV-1 variants in untreated individuals in Europe: implications for clinical management. *J Infect Dis*. Sep 15 2005;192(6):958-966. Available at http://www.ncbi.nlm.nih.gov/pubmed/16107947.

18. Gray RH, Li X, Kigozi G, et al. Increased risk of incident HIV during pregnancy in Rakai, Uganda: a prospective study. *Lancet*. Oct 1 2005;366(9492):1182-1188. Available at http://www.ncbi.nlm.nih.gov/pubmed/16198767.

19. Bernasconi D, Tavoschi L, Regine V, et al. Identification of recent HIV infections and of factors associated with virus acquisition among pregnant women in 2004 and 2006 in Swaziland. *J Clin Virol*. Jul 2010;48(3):180-183. Available at http://www.ncbi.nlm.nih.gov/pubmed/20537582.

20. Moodley D, Esterhuizen TM, Pather T, Chetty V, Ngaleka L. High HIV incidence during pregnancy: compelling reason for repeat HIV testing. *AIDS*. Jun 19 2009;23(10):1255-1259. Available at http://www.ncbi.nlm.nih.gov/pubmed/19455017.

21. Mugo NR, Heffron R, Donnell D, et al. Increased risk of HIV-1 transmission in pregnancy: a prospective study among African HIV-1-serodiscordant couples. *AIDS*. Sep 24 2011;25(15):1887-1895. Available at http://www.ncbi.nlm.nih.gov/pubmed/21785321.

22. Carpenter LM, Kamali A, Ruberantwari A, Malamba SS, Whitworth JA. Rates of HIV-1 transmission within marriage in rural Uganda in relation to the HIV sero-status of the partners. *AIDS*. Jun 18 1999;13(9):1083-1089. Available at http://www.ncbi.nlm.nih.gov/pubmed/10397539.

23. Brubaker SG, Bukusi EA, Odoyo J, Achando J, Okumu A, Cohen CR. Pregnancy and HIV transmission among HIV-discordant couples in a clinical trial in Kisumu, Kenya. *HIV Med*. May 2011;12(5):316-321. Available at http://www.ncbi.nlm.nih.gov/pubmed/21205129.

## Special Situations — Stopping Antiretroviral Drugs During Pregnancy (Last updated July 31, 2012; last reviewed July 31, 2012)

### Panel's Recommendations

- HIV-infected women receiving antiretroviral therapy (ART) who present for care during the first trimester should continue treatment during pregnancy **(AII)**. If an antiretroviral (ARV) drug regimen is stopped acutely for severe or life-threatening toxicity, severe pregnancy-induced hyperemesis unresponsive to antiemetics, or other acute illnesses that preclude oral intake, all ARV drugs should be stopped and reinitiated at the same time **(AIII)**.
- If an ARV drug regimen is being stopped electively and the patient is receiving a non-nucleoside reverse transcriptase inhibitor (NNRTI) drug, consideration should be given to either: (1) stopping the NNRTI first and continuing the other ARV drugs for a period of time or (2) switching from an NNRTI to a protease inhibitor (PI) before interruption and continuing the PI with the other ARV drugs for a period of time before electively stopping. The optimal interval between stopping an NNRTI and the other ARV drugs is unknown; at least 7 days is recommended. Given the potential for prolonged detectable efavirenz concentrations for >3 weeks in patients receiving efavirenz-based therapy, some experts recommend continuing the other ARV agents or substituting a PI plus two other agents for up to 30 days **(CIII)**.
- If nevirapine is stopped and more than 2 weeks have passed before restarting therapy, nevirapine should be restarted with the 2-week half-dose escalation period **(AII)**.

***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*

***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion*

Discontinuation of antiretroviral (ARV) drug regimens during pregnancy may be indicated in some situations, including serious drug-related toxicity, pregnancy-induced hyperemesis unresponsive to antiemetics, acute illnesses or planned surgeries that preclude oral intake, lack of available medication, or at patients' request.

HIV-infected women receiving antiretroviral therapy (ART) who present for care during the first trimester should continue treatment during pregnancy. Discontinuation of therapy could lead to an increase in viral load with possible decline in immune status and disease progression as well as adverse consequences for the fetus, including increased risk of *in utero* transmission of HIV. A recent analysis from a prospective cohort of 937 HIV-infected mother-child pairs found that interruption of ART during pregnancy, including interruption in the first and third trimesters, was independently associated with perinatal transmission. In the first trimester, the median time at interruption was 6 weeks' gestation and length of time without therapy was 8 weeks (interquartile range [IQR], 7–11 weeks); in the third trimester, the median time at interruption was 32 weeks and length of time without therapy was 6 weeks (IQR, 2–9 weeks). Although the perinatal transmission rate for the entire cohort was only 1.3%, transmission occurred in 4.9% (95% confidence interval [CI], 1.9%–13.2%; adjusted odds ratio [AOR] 10.33; $P = .005$) with first-trimester interruption and 18.2% (95% CI, 4.5%–72.7%; AOR 46.96; $P = .002$) with third-trimester interruption.[1] Although the use of efavirenz should be avoided during the first trimester when possible, therapy should not be interrupted in women taking the drug who present in the first trimester (see HIV-Infected Pregnant Women Who Are Currently Receiving Antiretroviral Treatment).

Continuation of all drugs during the intrapartum period generally is recommended. Women who are having elective cesarean delivery can take oral medications before the procedure and restart drugs following surgery. Because most drugs are given once or twice daily, it is likely that no doses would be missed or that at most the postpartum dose would be given a few hours late.

When short-term drug interruption is indicated, in most cases, all ARV drugs should be stopped and reintroduced at the same time. This can be problematic with drugs that have a long half-life. However, in conditions such as serious or life-threatening toxicity, severe pregnancy-induced hyperemesis unresponsive to antiemetics, or other acute illnesses precluding oral intake, the clinician has no choice but to stop all therapy at the same time. In the rare case in which a woman has limited oral intake that does not meet food requirements for certain ARV agents, decisions about the ARV regimen administered during the antepartum or intrapartum period should be made on an individual basis and in consultation with an HIV treatment expert.

Non-nucleoside reverse transcriptase inhibitor (NNRTI) drugs such as nevirapine and efavirenz have very long half-lives and can be detected for 21 days or longer after discontinuation; efavirenz has a longer half-life than nevirapine.[2-6] Because other drugs in the ARV regimen have shorter half-lives and are cleared more rapidly, only detectable NNRTI drug levels persist, resulting in subtherapeutic drug levels that can increase the risk of selection of NNRTI-resistant mutations. In addition, certain genetic polymorphisms, which may be more common among ethnic groups such as African Americans and Hispanics, may have the potential to result in a slower rate of clearance.[4, 6] To prevent prolonged exposure to a single drug, some experts recommend stopping the NNRTI first and continuing the other ARV drugs for a period of time.[3] However, the optimal interval between stopping an NNRTI and the other ARV drugs is unknown; detectable levels of NNRTIs may be present from <1 week to >3 weeks after discontinuation, with the longer duration primarily observed with efavirenz.[6] An alternative strategy is to substitute a protease inhibitor (PI) for the NNRTI and to continue the PI with dual nucleoside reverse transcriptase inhibitors (NRTIs) for a period of time. In a post-study analysis of the patients who interrupted therapy in the SMART trial, patients who were switched from an NNRTI- to a PI-based regimen before interruption had a lower rate of NNRTI-resistant mutation after interruption and a greater chance of HIV RNA resuppression after restarting therapy than those who stopped all the drugs simultaneously or stopped the NNRTI before the dual NRTIs.[7]

The optimal duration for continuing either dual nucleosides or the substituted PI-based regimen after stopping the NNRTI is unknown, but a minimum of 7 days is recommended based on studies to reduce resistance following single-dose nevirapine.[8, 9]

A pharmacokinetic study of nevirapine elimination in African adults following cessation of steady-state nevirapine-containing regimens found that nevirapine concentrations were estimated to have fallen below 20 ng/mL in 3 of 19 (16%) and 14 of 19 (74%) subjects by 7 and 14 days, respectively, after the cessation of dosing.[10] Elimination half-life was 39 hours in these subjects, considerably shorter than that observed after peripartum exposure to single doses of nevirapine (average 55–60 hours), likely related to induction of nevirapine metabolism with chronic nevirapine exposure.[2, 11, 12] Because efavirenz concentrations have the potential to be detectable for more than 3 weeks, some experts suggest that if efavirenz-based therapy is stopped, the dual NRTIs or PI may need to be continued for up to 30 days. Further research is needed to assess appropriate strategies for stopping NNRTI-containing combination regimens.

Another consideration is reintroduction of nevirapine if it is temporarily stopped and subsequently restarted. A 2-week, half-dose escalation currently is recommended in patients who are started on nevirapine. Dose escalation is necessary because nevirapine induces its own metabolism by inducing cytochrome P450 3A4 liver metabolic enzymes; thus, initial administration of the full therapeutic dose will result in elevated drug levels until metabolic enzyme induction has occurred. In cases where nevirapine has been discontinued for more than 2 weeks, another 2-week dose escalation is recommended when it is reintroduced.

## References


1. Galli L, Puliti D, Chiappini E, et al. Is the interruption of antiretroviral treatment during pregnancy an additional major risk factor for mother-to-child transmission of HIV type 1? *Clin Infect Dis.* May 1 2009;48(9):1310-1317. Available at http://www.ncbi.nlm.nih.gov/pubmed/19309307.

2. Cressey TR, Jourdain G, Lallemant MJ, et al. Persistence of nevirapine exposure during the postpartum period after intrapartum single-dose nevirapine in addition to zidovudine prophylaxis for the prevention of mother-to-child transmission of HIV-1. *J Acquir Immune Defic Syndr*. Mar 1 2005;38(3):283-288. Available at http://www.ncbi.nlm.nih.gov/pubmed/15735445.

3. Mackie NE, Fidler S, Tamm N, et al. Clinical implications of stopping nevirapine-based antiretroviral therapy: relative pharmacokinetics and avoidance of drug resistance. *HIV Med*. May 2004;5(3):180-184. Available at http://www.ncbi.nlm.nih.gov/pubmed/15139985.

4. Nolan M, Fowler MG, Mofenson LM. Antiretroviral prophylaxis of perinatal HIV-1 transmission and the potential impact of antiretroviral resistance. *J Acquir Immune Defic Syndr*. Jun 1 2002;30(2):216-229. Available at http://www.ncbi.nlm.nih.gov/pubmed/12045685.

5. Sadiq ST, Fredericks S, Khoo SH, Rice P, Holt DW. Efavirenz detectable in plasma 8 weeks after stopping therapy and subsequent development of non-nucleoside reverse transcriptase inhibitor-associated resistance. *AIDS*. Oct 14 2005;19(15):1716-1717. Available at http://www.ncbi.nlm.nih.gov/pubmed/16184054.

6. Ribaudo HJ, Haas DW, Tierney C, et al. Pharmacogenetics of plasma efavirenz exposure after treatment discontinuation: an Adult AIDS Clinical Trials Group Study. *Clin Infect Dis*. Feb 1 2006;42(3):401-407. Available at http://www.ncbi.nlm.nih.gov/pubmed/16392089.

7. Fox Z, Phillips A, Cohen C, et al. Viral resuppression and detection of drug resistance following interruption of a suppressive non-nucleoside reverse transcriptase inhibitor-based regimen. *AIDS*. Nov 12 2008;22(17):2279-2289. Available at http://www.ncbi.nlm.nih.gov/pubmed/18981767.

8. McIntyre JA, Hopley M, Moodley D, et al. Efficacy of short-course AZT plus 3TC to reduce nevirapine resistance in the prevention of mother-to-child HIV transmission: a randomized clinical trial. *PLoS Med*. Oct 2009;6(10):e1000172. Available at http://www.ncbi.nlm.nih.gov/pubmed/19859531.

9. Farr SL, Nelson JA, Ng'ombe TJ, et al. Addition of 7 days of zidovudine plus lamivudine to peripartum single-dose nevirapine effectively reduces nevirapine resistance postpartum in HIV-infected mothers in Malawi. *J Acquir Immune Defic Syndr*. Aug 2010;54(5):515-523. Available at http://www.ncbi.nlm.nih.gov/pubmed/20672451.

10. Kikaire B, Khoo S, Walker AS, et al. Nevirapine clearance from plasma in African adults stopping therapy: a pharmacokinetic substudy. *AIDS*. Mar 30 2007;21(6):733-737. Available at http://www.ncbi.nlm.nih.gov/pubmed/17413694.

11. Muro E, Droste JA, Hofstede HT, Bosch M, Dolmans W, Burger DM. Nevirapine plasma concentrations are still detectable after more than 2 weeks in the majority of women receiving single-dose nevirapine: implications for intervention studies. *J Acquir Immune Defic Syndr*. Aug 1 2005;39(4):419-421. Available at http://www.ncbi.nlm.nih.gov/pubmed/16010163.

12. Musoke P, Guay LA, Bagenda D, et al. A phase I/II study of the safety and pharmacokinetics of nevirapine in HIV-1-infected pregnant Ugandan women and their neonates (HIVNET 006). *AIDS*. Mar 11 1999;13(4):479-486. Available at http://www.ncbi.nlm.nih.gov/pubmed/10197376.

## Special Situations — Failure of Viral Suppression (Last updated July 31, 2012; last reviewed July 31, 2012)

### Panel's Recommendations

- If an ultrasensitive HIV RNA assay indicates failure of viral suppression (that is, detectable virus) after an adequate period of treatment:
  - Assess resistance and adherence **(AII)**.
  - Consult an HIV treatment expert **(AIII)**.
- Scheduled cesarean delivery is recommended for HIV-infected pregnant women who have HIV RNA levels >1,000 copies/mL near the time of delivery **(AII)**.

***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*

***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion*

A three-pronged approach is indicated for management of women on antiretroviral (ARV) regimens who have suboptimal suppression of HIV RNA (that is, detectable virus at any time during pregnancy using ultrasensitive assays). They should a) be evaluated for resistant virus (if plasma HIV RNA is >500–1,000 copies/mL); b) assessed for adherence, tolerability, incorrect dosing, or potential problems with absorption (such as with nausea/vomiting or lack of attention to food requirements); and, c) consideration should be given to modifying the ARV regimen. Experts in the care of ARV-experienced adults should be consulted, particularly if a change in drug regimen is necessary. Hospitalization may be considered for directly observed drug administration, adherence education, and treatment of comorbidities such as nausea and vomiting.

Among 662 pregnancies followed in Italy between 2001 and 2008, treatment modification during pregnancy was independently associated with an HIV-1 RNA level >400 copies/mL in late pregnancy (adjusted odds ratio, 1.66; 95% confidence interval, 1.07–2.57; $P = 0.024$), highlighting the importance of using potent and well-tolerated regimens during pregnancy to maximize effectiveness and minimize need to modify treatment.[1]

HIV RNA levels should be assessed 2–4 weeks after an ARV drug regimen is initiated or changed to provide an initial assessment of effectiveness.[2] Baseline HIV RNA levels have been shown to affect the time to response in both pregnant and non-pregnant individuals.[3] Most patients with an adequate viral response at 24 weeks have had at least a 1-log copies/mL HIV RNA decrease within 1–4 weeks after starting therapy.[2] Treatment-naive individuals should have HIV RNA <400 copies/mL after 24 weeks of treatment and <50 copies/mL after 48 weeks of treatment. The role of therapeutic drug monitoring in reducing the risk of virologic failure is still undefined.[4]

Because maternal antenatal viral load correlates with risk of perinatal transmission of HIV, suppression of HIV RNA to undetectable levels should be achieved as rapidly as possible. The addition of raltegravir in late pregnancy has been suggested for women who have high viral loads and/or in whom multiple drug-resistant mutations have resulted in incomplete suppression of viremia because of the ability of raltegravir to rapidly suppress viral load (approximately 2-log copies/mL decrease by Week 2 of therapy).[5-8] However, the efficacy and safety of this approach have not been evaluated and only anecdotal reports are available. In the setting of a failing regimen related to nonadherence and/or resistance, there are concerns that the addition of a single agent may further increase risk of resistance and potential loss of future effectiveness with raltegravir. Therefore, at the current time, this approach cannot be recommended. Scheduled cesarean delivery is

recommended for HIV-infected pregnant women who have HIV RNA levels >1,000 copies/mL near the time of delivery (see Transmission and Mode of Delivery).

## References


1. Floridia M, Ravizza M, Pinnetti C, et al. Treatment change in pregnancy is a significant risk factor for detectable HIV-1 RNA in plasma at end of pregnancy. *HIV Clin Trials.* Nov-Dec 2010;11(6):303-311. Available at http://www.ncbi.nlm.nih.gov/pubmed/21239358.
2. Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents. Department of Health and Human Services. Available at http://aidsinfo.nih.gov/contentfiles/lvguidelines/AdultandAdolescentGL.pdf. Accessed June 7, 2012.
3. European Collaborative Study, Patel D, Cortina-Borja M, Thorne C, Newell ML. Time to undetectable viral load after highly active antiretroviral therapy initiation among HIV-infected pregnant women. *Clin Infect Dis*. Jun 15 2007;44(12):1647-1656. Available at http://www.ncbi.nlm.nih.gov/pubmed/17516411.
4. Liu X, Ma Q, Zhang F. Therapeutic drug monitoring in highly active antiretroviral therapy. *Expert Opin Drug Saf*. Sep 2010;9(5):743-758. Available at http://www.ncbi.nlm.nih.gov/pubmed/20350281.
5. Grinsztejn B, Nguyen BY, Katlama C, et al. Safety and efficacy of the HIV-1 integrase inhibitor raltegravir (MK-0518) in treatment-experienced patients with multidrug-resistant virus: a phase II randomised controlled trial. *Lancet*. Apr 14 2007;369(9569):1261-1269. Available at http://www.ncbi.nlm.nih.gov/pubmed/17434401.
6. Papendorp SG, van den Berk GE. Preoperative use of raltegravir-containing regimen as induction therapy: very rapid decline of HIV-1 viral load. *AIDS*. Mar 27 2009;23(6):739. Available at http://www.ncbi.nlm.nih.gov/pubmed/19279447.
7. Pinnetti C, Baroncelli S, Villani P, et al. Rapid HIV-RNA decline following addition of raltegravir and tenofovir to ongoing highly active antiretroviral therapy in a woman presenting with high-level HIV viraemia at week 38 of pregnancy. *J Antimicrob Chemother*. Sep 2010;65(9):2050-2052. Available at http://www.ncbi.nlm.nih.gov/pubmed/20630894.
8. McKeown DA, Rosenvinge M, Donaghy S, et al. High neonatal concentrations of raltegravir following transplacental transfer in HIV-1 positive pregnant women. *AIDS*. Sep 24 2010;24(15):2416-2418. Available at http://www.ncbi.nlm.nih.gov/pubmed/20827058.

## Monitoring of the Woman and Fetus During Pregnancy (Last updated July 31, 2012; last reviewed July 31, 2012)

### Panel's Recommendations

- Plasma HIV RNA levels should be monitored at the initial visit **(AI)**; 2 to 4 weeks after initiating (or changing) antiretroviral (ARV) drug regimens **(BI)**; monthly until RNA levels are undetectable **(BIII)**; and then at least every 3 months during pregnancy **(BIII)**. HIV RNA levels also should be assessed at approximately 34 to 36 weeks' gestation to inform decisions about mode of delivery (see Transmission and Mode of Delivery) **(AIII)**.
- CD4 T-lymphocyte (CD4-cell) count should be monitored at the initial antenatal visit **(AI)** and at least every 3 months during pregnancy **(BIII)**. Monitoring of CD4-cell count can be performed every 6 months in patients on antiretroviral therapy (ART) for more than 2 to 3 years who are adherent to therapy, clinically stable, and have sustained viral suppression **(CIII)**.
- Genotypic ARV drug-resistance testing should be performed at baseline in all HIV-infected pregnant women with HIV RNA levels >500 to 1,000 copies/mL, whether they are ARV naive or currently on therapy **(AIII)**. Repeat testing is indicated following initiation of an ARV regimen in women who have suboptimal viral suppression or who have persistant viral rebound to detectable levels after prior viral suppression on an ARV regimen **(AII)**.
- Monitoring for complications of ARV drugs during pregnancy should be based on what is known about the adverse effects of the drugs a woman is receiving **(AIII)**.
- First-trimester ultrasound is recommended to confirm gestational age and, if scheduled cesarean delivery is necessary, to guide timing of the procedure (see Transmission and Mode of Delivery) **(AII)**.
- In women on effective ART, no perinatal transmissions have been reported after amniocentesis, but a small risk of transmission cannot be ruled out. If amniocentesis is indicated in HIV-infected women, it should be done only after initiation of an effective ART regimen and, if possible, when HIV RNA levels are undetectable **(BIII)**. In women with detectable HIV RNA levels in whom amniocentesis is deemed necessary, consultation with an expert should be considered.

***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*

***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion*

Viral load should be monitored in HIV-infected pregnant women at the initial visit, 2 to 4 weeks after initiating or changing antiretroviral (ARV) regimens, monthly until undetectable, and at least every 3 months thereafter. If adherence is a concern, more frequent monitoring is recommended because of the potential increased risk of perinatal HIV infection associated with detectable HIV viremia during pregnancy. More frequent viral load monitoring is recommended in pregnant versus non-pregnant individuals because of the urgency to lower viral load as rapidly as possible to reduce the risk of perinatal transmission. Therefore, there is a need to identify pregnant women in whom the decline in viral load is slower than expected. Adult ARV guidelines note that patients should have a decrease in plasma HIV RNA level by at least one $\log_{10}$ copies/mL within 1 month after initiation of potent therapy.[1] Viral suppression generally is achieved in 16 to 24 weeks in ARV-naive treatment-adherent individuals who do not harbor resistance mutations to the drugs they are receiving but, in rare cases, it may take longer. Viral load also should be assessed at approximately 34 to 36 weeks' gestation to inform decisions about mode of delivery (see Transmission and Mode of Delivery).

In HIV-infected pregnant women, CD4 T-lymphocyte (CD4-cell) count should be monitored at the initial visit and at least every 3 months during pregnancy. CD4-cell counts can be performed every 6 months in

patients on antiretroviral therapy (ART) for more than 2 to 3 years who are adherent to therapy, clinically stable, and have sustained viral suppression. Because of physiologic changes such as hemodilution that are associated with pregnancy, CD4 percentage may be more stable than absolute CD4 count during pregnancy.[2-5] Nevertheless, most clinicians still rely on absolute CD4 count to evaluate immune status during pregnancy because parameters for initiating therapy are based on those values.

Whenever feasible, ARV drug-resistance testing should be performed in HIV-infected pregnant women before initiation of ARV drugs if HIV RNA levels are above the threshold for resistance testing (that is, >500–1,000 copies/mL) unless delay in getting results back would lead to delay in starting ARV for prevention of mother-to-child transmission. Testing also should be performed on women taking an ARV regimen who have suboptimal viral suppression or who have persistant viral rebound to detectable levels after prior viral suppression on an ARV regimen (see Antiretroviral Drug Resistance and Resistance Testing in Pregnancy). Drug-resistance testing in the setting of virologic failure should be performed while patients are receiving ARV drugs or within 4 weeks after discontinuation of drugs. Genotypic testing is preferable to phenotypic testing because it costs less, has a faster turnaround time, and is more sensitive for detection of mixtures of wild-type and resistant virus.

Monitoring for potential complications of ARV drugs during pregnancy should be based on what is known about the adverse effects of the drugs a woman is receiving. For example, routine hematologic monitoring is recommended for women receiving zidovudine-containing regimens and routine renal monitoring should be recommended for women on tenofovir. Liver function should be monitored in all women receiving ARV drugs. Hepatic dysfunction has been observed in pregnant women on protease inhibitors, and hepatic steatosis and lactic acidosis in pregnancy have been related to nucleoside reverse transcriptase inhibitor use. Women with CD4-cell counts >250 cells/mm$^3$ are thought to be at particular risk of developing symptomatic, rash-associated, nevirapine-associated hepatotoxicity within the first 18 weeks after initiation of therapy. However, recent data from an international study did not show the same association between nevirapine toxicity and CD4-cell counts among pregnant women.[6] Additional data from a 2010 study suggest that abnormal liver transaminase levels at baseline may be more predictive of risk than CD4-cell count.[7] Transaminase levels should be monitored more frequently and carefully in pregnant women initiating therapy with nevirapine, and they should also be watched for clinical symptoms of potential hepatotoxicity (see Nevirapine and Hepatic/Rash Toxicity). The drug can be used cautiously with careful monitoring in women with mildly abnormal liver function tests at the time of ARV drug initiation.

First-trimester ultrasound is recommended to confirm gestational age and, if scheduled cesarean delivery is necessary, to guide potential timing because such deliveries for prevention of perinatal transmission of HIV should be performed at 38 weeks' gestation (see Transmission and Mode of Delivery).[8, 9] In patients who are not seen until later in gestation, second-trimester ultrasound can be used for both anatomical scanning and determination of gestational age.

Although data are still somewhat limited, the risk of transmission does not appear to be increased with amniocentesis or other invasive diagnostic procedures in women receiving effective ART resulting in viral suppression. This is in contrast to the pre-ART era, during which invasive procedures such as amniocentesis and chorionic villus sampling (CVS) were associated with a two- to fourfold increased risk of perinatal transmission of HIV.[10-13] Although no transmissions have occurred among 159 cases reported to date of amniocentesis or other invasive diagnostic procedures among women on effective ART regimens, a small increase in risk of transmission cannot be ruled out.[14-17] HIV-infected women who have indications for invasive testing in pregnancy, such as abnormal ultrasound or aneuploidy screening, should be counseled about the potential risk of transmission of HIV along with other risks of the procedure and allowed to make an informed decision about testing. Some experts consider CVS and cordocentesis too risky to offer to HIV-infected women and they recommend limiting invasive procedures to amniocentesis,[15] but existing data on

transmission risk associated with these procedures are limited. At a minimum, HIV-infected pregnant women should receive effective ART before undergoing any invasive prenatal testing and, ideally, have an undetectable HIV RNA level at the time of the procedure. In women with detectable HIV RNA levels for whom amniocentesis is deemed necessary, consultation with an expert should be considered. These procedures should be done under continuous ultrasound guidance and, if possible, the placenta should be avoided.

## References


1. Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents. Department of Health and Human Services. Available at http://aidsinfo.nih.gov/contentfiles/lvguidelines/AdultandAdolescentGL.pdf. Accessed June 19, 2012.
2. Miotti PG, Liomba G, Dallabetta GA, Hoover DR, Chiphangwi JD, Saah AJ. T lymphocyte subsets during and after pregnancy: analysis in human immunodeficiency virus type 1-infected and -uninfected Malawian mothers. *J Infect Dis*. Jun 1992;165(6):1116-1119. Available at http://www.ncbi.nlm.nih.gov/pubmed/1583330.
3. Tuomala RE, Kalish LA, Zorilla C, et al. Changes in total, CD4+, and CD8+ lymphocytes during pregnancy and 1 year postpartum in human immunodeficiency virus-infected women. The Women and Infants Transmission Study. *Obstet Gynecol*. Jun 1997;89(6):967-974. Available at http://www.ncbi.nlm.nih.gov/pubmed/9170476.
4. Ekouevi DK, Inwoley A, Tonwe-Gold B, et al. Variation of CD4 count and percentage during pregnancy and after delivery: implications for HAART initiation in resource-limited settings. *AIDS Res Hum Retroviruses*. Dec 2007;23(12):1469-1474. Available at http://www.ncbi.nlm.nih.gov/pubmed/18160003.
5. Towers CV, Rumney PJ, Ghamsary MG. Longitudinal study of CD4+ cell counts in HIV-negative pregnant patients. *J Matern Fetal Neonatal Med*. Oct 2010;23(10):1091-1096. Available at http://www.ncbi.nlm.nih.gov/pubmed/20121393.
6. Peters PJ, Polle N, Zeh C, et al. Nevirapine-Associated Hepatotoxicity and Rash among HIV-Infected Pregnant Women in Kenya. *J Int Assoc Physicians AIDS Care (Chic)*. Mar-Apr 2012;11(2):142-149. Available at http://www.ncbi.nlm.nih.gov/pubmed/22020069.
7. Peters PJ, Stringer J, McConnell MS, et al. Nevirapine-associated hepatotoxicity was not predicted by CD4 count ≥250 cells/muL among women in Zambia, Thailand and Kenya. *HIV Med*. Nov 2010;11(10):650-660. Available at http://www.ncbi.nlm.nih.gov/pubmed/20659176.
8. ACOG Committee on Practice Bulletins. ACOG Practice Bulletin No. 58. Ultrasonography in pregnancy. *Obstet Gynecol*. Dec 2004;104(6):1449-1458. Available at http://www.ncbi.nlm.nih.gov/pubmed/15572512.
9. Bennett KA, Crane JM, O'Shea P, Lacelle J, Hutchens D, Copel JA. First trimester ultrasound screening is effective in reducing postterm labor induction rates: a randomized controlled trial. *Am J Obstet Gynecol*. Apr 2004;190(4):1077-1081. Available at http://www.ncbi.nlm.nih.gov/pubmed/15118645.
10. Mandelbrot L, Mayaux MJ, Bongain A, et al. Obstetric factors and mother-to-child transmission of human immunodeficiency virus type 1: the French perinatal cohorts. SEROGEST French Pediatric HIV Infection Study Group. *Am J Obstet Gynecol*. Sep 1996;175(3 Pt 1):661-667. Available at http://www.ncbi.nlm.nih.gov/pubmed/8828431.
11. Tess BH, Rodrigues LC, Newell ML, Dunn DT, Lago TD. Breastfeeding, genetic, obstetric and other risk factors associated with mother-to-child transmission of HIV-1 in Sao Paulo State, Brazil. Sao Paulo Collaborative Study for Vertical Transmission of HIV-1. *AIDS*. Mar 26 1998;12(5):513-520. Available at http://www.ncbi.nlm.nih.gov/pubmed/9543450.
12. Shapiro DE, Sperling RS, Mandelbrot L, Britto P, Cunningham BE. Risk factors for perinatal human immunodeficiency virus transmission in patients receiving zidovudine prophylaxis. Pediatric AIDS Clinical Trials Group protocol 076 Study Group. *Obstet Gynecol*. Dec 1999;94(6):897-908. Available at http://www.ncbi.nlm.nih.gov/pubmed/10576173.
13. Maiques V, Garcia-Tejedor A, Perales A, Cordoba J, Esteban RJ. HIV detection in amniotic fluid samples. Amniocentesis can be performed in HIV pregnant women? *Eur J Obstet Gynecol Reprod Biol*. Jun 10 2003;108(2):137-

141. Available at http://www.ncbi.nlm.nih.gov/pubmed/12781400.

14. Somigliana E, Bucceri AM, Tibaldi C, et al. Early invasive diagnostic techniques in pregnant women who are infected with the HIV: a multicenter case series. *Am J Obstet Gynecol*. Aug 2005;193(2):437-442. Available at http://www.ncbi.nlm.nih.gov/pubmed/16098867.

15. Coll O, Suy A, Hernandez S, et al. Prenatal diagnosis in human immunodeficiency virus-infected women: a new screening program for chromosomal anomalies. *Am J Obstet Gynecol*. Jan 2006;194(1):192-198. Available at http://www.ncbi.nlm.nih.gov/pubmed/16389031.

16. Ekoukou D, Khuong-Josses MA, Ghibaudo N, Mechali D, Rotten D. Amniocentesis in pregnant HIV-infected patients. Absence of mother-to-child viral transmission in a series of selected patients. *Eur J Obstet Gynecol Reprod Biol*. Oct 2008;140(2):212-217. Available at http://www.ncbi.nlm.nih.gov/pubmed/18584937.

17. Mandelbrot L, Jasseron C, Ekoukou D, et al. Amniocentesis and mother-to-child human immunodeficiency virus transmission in the Agence Nationale de Recherches sur le SIDA et les Hepatites Virales French Perinatal Cohort. *Am J Obstet Gynecol*. Feb 2009;200(2):160 e161-169. Available at http://www.ncbi.nlm.nih.gov/pubmed/18986640.

# Special Considerations Regarding the Use of Antiretroviral Drugs by HIV-Infected Pregnant Women and Their Infants

## Overview (Last updated July 31, 2012; last reviewed July 31, 2012)

Recommendations regarding the choice of antiretroviral (ARV) drugs for HIV-infected pregnant women are subject to unique considerations. These include:

a. possible changes in dosing requirements resulting from physiologic changes associated with pregnancy;
b. potential toxicities of ARV drugs that may be exacerbated in pregnant women;
c. the pharmacokinetics (PKs) and toxicity of transplacentally transferred drugs; and
d. the potential short- and long-term effects of the ARV drug on fetuses and newborns, including the potential for preterm birth, teratogenicity, mutagenicity, or carcinogenicity.

ARV drug recommendations for HIV-infected pregnant women have been based on the concept that drugs of known benefit to women should not be withheld during pregnancy unless there are known adverse effects on the mother, fetus, or infant and unless these adverse effects outweigh the benefits to the woman.[1] Pregnancy should not preclude the use of optimal drug regimens. The decision to use any ARV drug during pregnancy should be made by a woman after discussing with her health care provider the known and potential benefits and risks to her and her fetus.

Although clinical data are more limited on ARV drugs in pregnant women than in non-pregnant individuals, sufficient data exist on which to base recommendations related to drug choice for many of the available ARV drugs. Table 5 provides information on PKs in pregnancy and pregnancy-related concerns for each of the available ARV drugs; drugs are classified for use in pregnancy as preferred, alternative, use in special circumstances, insufficient data to recommend use, and not recommended (see General Principles Regarding Use of Antiretroviral Drugs during Pregnancy). This table should be used in conjunction with the *Guidelines for the Use of Antiretroviral Agents in HIV-1-Infected Adults and Adolescents* when developing treatment regimens for pregnant women.

## Reference

1. Minkoff H, Augenbraun M. Antiretroviral therapy for pregnant women. *Am J Obstet Gynecol*. Feb 1997;176(2):478-489. Available at http://www.ncbi.nlm.nih.gov/pubmed/9065202.

## Pharmacokinetic Changes (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendation |
|---|
| • Altered dosing during pregnancy may be required for some protease inhibitors, such as lopinavir/ritonavir (see Table 5) **(AII)** |

***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*

***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion*

Physiologic changes that occur during pregnancy can affect drug absorption, distribution, biotransformation, and elimination, thereby also affecting requirements for drug dosing and potentially altering the susceptibility of pregnant women to drug toxicity.[1, 2] During pregnancy, gastrointestinal transit time becomes prolonged; body water and fat increase throughout gestation and are accompanied by increases in cardiac output, ventilation, and liver and renal blood flow; plasma protein concentrations decrease; renal sodium reabsorption increases; and changes occur in cellular transporters and drug metabolizing enzymes in the liver and intestine. Placental transport of drugs, compartmentalization of drugs in the embryo/fetus and placenta, biotransformation of drugs by the fetus and placenta, and elimination of drugs by the fetus also can affect drug pharmacokinetics (PKs) in the pregnant woman.

Currently available data on the PKs of antiretroviral agents in pregnancy are summarized in Table 5. In general, the PKs of nucleoside reverse transcriptase inhibitors and non-nucleoside reverse transcriptase inhibitors are similar in pregnant and non-pregnant women, whereas protease inhibitor (PI) PKs are more variable, particularly in later pregnancy. Current data suggest that with standard adult dosing, plasma concentrations of lopinavir/ritonavir, atazanavir, darunavir, and nelfinavir are reduced during the second and/or third trimesters (see Table 5). The need for a dose adjustment depends on the PI, an individual patient's treatment experience, and use (if any) of concomitant medications with potential for drug interactions.[3-10]

## References


1. Mirochnick M, Capparelli E. Pharmacokinetics of antiretrovirals in pregnant women. *Clin Pharmacokinet*. 2004;43(15):1071-1087. Available at http://www.ncbi.nlm.nih.gov/pubmed/15568888.
2. Roustit M, Jlaiel M, Leclercq P, Stanke-Labesque F. Pharmacokinetics and therapeutic drug monitoring of antiretrovirals in pregnant women. *Br J Clin Pharmacol*. Aug 2008;66(2):179-195. Available at http://www.ncbi.nlm.nih.gov/pubmed/18537960.
3. Bristol-Myers Squibb. Reyataz drug label, 2/4/2011. Available at http://www.accessdata.fda.gov/drugsatfda_docs/label/2011/021567s025lbl.pdf. Accessed on June 26, 2012.
4. Stek AM, Mirochnick M, Capparelli E, et al. Reduced lopinavir exposure during pregnancy. *AIDS*. Oct 3 2006;20(15):1931-1939. Available at http://www.ncbi.nlm.nih.gov/pubmed/16988514.
5. Villani P, Floridia M, Pirillo MF, et al. Pharmacokinetics of nelfinavir in HIV-1-infected pregnant and nonpregnant women. *Br J Clin Pharmacol*. Sep 2006;62(3):309-315. Available at http://www.ncbi.nlm.nih.gov/pubmed/16934047.
6. Bryson YJ, Mirochnick M, Stek A, et al. Pharmacokinetics and safety of nelfinavir when used in combination with zidovudine and lamivudine in HIV-infected pregnant women: Pediatric AIDS Clinical Trials Group (PACTG) Protocol 353. *HIV Clin Trials*. Mar-Apr 2008;9(2):115-125. Available at http://www.ncbi.nlm.nih.gov/pubmed/18474496.

7. Mirochnick M, Best BM, Stek AM, et al. Lopinavir exposure with an increased dose during pregnancy. *J Acquir Immune Defic Syndr*. Dec 15 2008;49(5):485-491. Available at http://www.ncbi.nlm.nih.gov/pubmed/18989231.

8. Read JS, Best BM, Stek AM, et al. Pharmacokinetics of new 625 mg nelfinavir formulation during pregnancy and postpartum. *HIV Med*. Nov 2008;9(10):875-882. Available at http://www.ncbi.nlm.nih.gov/pubmed/18795962.

9. Bouillon-Pichault M, Jullien V, Azria E, et al. Population analysis of the pregnancy-related modifications in lopinavir pharmacokinetics and their possible consequences for dose adjustment. *J Antimicrob Chemother*. Jun 2009;63(6):1223-1232. Available at http://www.ncbi.nlm.nih.gov/pubmed/19389715.

10. Best BM, Stek AM, Mirochnick M, et al. Lopinavir tablet pharmacokinetics with an increased dose during pregnancy. *J Acquir Immune Defic Syndr*. Aug 2010;54(4):381-388. Available at http://www.ncbi.nlm.nih.gov/pubmed/20632458.

## Teratogenicity (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendations |
|---|
| • All cases of antiretroviral (ARV) drug exposure during pregnancy should be reported to the Antiretroviral Pregnancy Registry (see details at http://www.APRegistry.com) **(AIII)**. |
| • Non-pregnant women of childbearing potential should undergo pregnancy testing before initiation of efavirenz and receive counseling about the potential risk to the fetus and desirability of avoiding pregnancy while on efavirenz-containing regimens **(AIII)**.<br>o Alternate ARV regimens that do not include efavirenz should be strongly considered in women who are (1) planning to become pregnant or (2) sexually active and not using effective contraception, assuming these alternative regimens are acceptable to the provider and are not thought to compromise the woman's health **(BIII)**. |
| • Because the risk of neural tube defects is restricted to the first 5 to 6 weeks of pregnancy and pregnancy is rarely recognized before 4 to 6 weeks of pregnancy, and unnecessary changes in ARV drugs during pregnancy may be associated with loss of viral control and increased risk of perinatal transmission, efavirenz can be continued in pregnant women receiving an efavirenz-based regimen who present for antenatal care in the first trimester, provided the regimen produces virologic suppression (see HIV-Infected Pregnant Women Who are Currently Receiving Antiretroviral Treatment) **(CIII)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*<br>***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

The potential harm to the fetus from maternal ingestion of a specific drug depends not only on the drug itself but also on the dose ingested; the gestational age of the fetus at exposure; the duration of exposure; the interaction with other agents to which the fetus is exposed; and, to an unknown extent, the genetic makeup of mother and fetus.

Information regarding the safety of drugs in pregnancy is derived from animal toxicity data, anecdotal experience, registry data, and clinical trials. Data are limited for antiretroviral (ARV) drugs, particularly when used in combination therapy. Drug choice should be individualized and must be based on discussion with a woman and available data from preclinical and clinical testing of the individual drugs. Preclinical data include results of *in vitro* and animal *in vivo* screening tests for carcinogenicity, clastogenicity/mutagenicity, and reproductive and teratogenic effects. However, the predictive value of such tests for adverse effects in humans is unknown. For example, of approximately 1,200 known animal teratogens, only about 30 are known to be teratogenic in humans.[1] Limited data exist regarding placental passage, pharmacokinetics and safety in pregnancy, and long-term safety for exposed infants for the Food and Drug Administration (FDA)-approved ARV drugs (see Supplement: Safety and Toxicity of Individual Antiretroviral Agents in Pregnancy). In general, reports of birth defects in fetuses/infants of women enrolled in observational studies who receive ARV regimens during pregnancy are reassuring and find no difference in rates of birth defects for first-trimester compared with later exposures.[2-4] However, concerns have been raised about the risk of several ARV agents.

Significant malformations were observed in 3 of 20 infant cynomolgus monkeys receiving efavirenz from gestational Days 20 to 150 at a dose resulting in plasma concentrations comparable to systemic human exposure at therapeutic dosage.[5] The malformations included anencephaly and unilateral anophthalmia in one, microphthalmia in another, and cleft palate in the third. Among pregnancies prospectively reported to the Antiretroviral Pregnancy Registry through January 2012 that had exposure to efavirenz-based regimens, a

2.7% incidence of overall birth defects was seen with first-trimester exposure, a proportion not significantly different from that observed among U.S. births in the general population.[6] Defects reported prospectively included 1 report of myelomeningocele and a separate report of anophthalmia. The case of anophthalmia included severe oblique facial clefts and amniotic banding that is known to be associated with anophthalmia.[6] In addition, 6 cases of central nervous system defects, including myelomeningocele, have been retrospectively reported in infants born to mothers receiving efavirenz during the first trimester.[5] However, retrospective reports can be biased toward reporting of more unusual and severe cases and are less likely to be representative of the general population experience.

A meta-analysis including data from 9 cohorts with prospective reporting on 1,132 first-trimester exposures did not find an increased risk of overall birth defects in infants born to women on efavirenz during the first trimester compared with those on other ARV drugs during the first trimester (relative risk [RR] 0.87; 95% confidence interval [CI], 0.61–1.24).[7] One neural tube defect occurred among 1,256 live births. An update to the meta-analysis included 181 additional live births with first-trimester efavirenz exposure and had similar results; the RR of overall birth defects on efavirenz versus non-efavirenz regimens was 0.85 (95% CI, 0.61–1.20), and 1 neural tube defect (the same as previous) was observed, giving an incidence of 0.07% (95% CI, 0.002–0.39).[8] However, the number of reported first-trimester efavirenz exposures still remains insufficient to rule out a significant 2- to 3-fold increase in low-incidence birth defects (incidence of neural tube defects in the general U.S. population is 0.02–0.2%).

In contrast to the meta-analysis, the Pediatric AIDS Clinical Trials Protocols (PACTG) 219 and 219C studies reported a higher defect rate in infants with first-trimester exposure to efavirenz compared with those without first-trimester efavirenz exposure (adjusted odds ratio 4.31; 95% CI, 1.56–11.86). However, only 32 infants had efavirenz exposure. PACTG protocol P1025 is a companion study of PACTG 219 with considerable overlap in cases enrolled. Although P1025 reports a significant increased risk of congenital anomalies in infants born between 2002 and 2007 with first-trimester exposure to efavirenz, there is overlap in the defect cases between the 2 studies and only 42 infants are included in this analysis. Thus, additional data are needed on first-trimester efavirenz exposures to be able to more conclusively determine if risk of neural tube defects or other malformations is elevated.

Although a causal relationship has not been established between these events and the use of efavirenz, in light of similar findings in primates, efavirenz has been classified as FDA Pregnancy Category D. Because of the potential for teratogenicity, pregnancy should be avoided in women receiving efavirenz, and treatment with efavirenz should be avoided during the first trimester (the primary period of fetal organogenesis) whenever possible. Women of childbearing potential should undergo pregnancy testing before initiation of efavirenz and should be counseled about the potential risk to the fetus and desirability of avoiding pregnancy while on efavirenz-containing regimens. Alternate ARV regimens that do not include efavirenz should be strongly considered in women who are planning to become pregnant or who are sexually active and not using effective contraception if such alternative regimens are acceptable to provider and patient and will not compromise the woman's health. However, the Panel now recommends that efavirenz can be continued in women who present for care in the first trimester and are receiving efavirenz-based ARV therapy that is effective in suppressing viral replication. This is because the neural tube closes at 36 to 39 days after the last menstrual period; hence the risk of neural tube defects is restricted to the first 5 to 6 weeks of pregnancy (and pregnancy is rarely recognized before 5–6 weeks of pregnancy), and unnecessary changes in ARV drugs during pregnancy may be associated with a loss of virologic control and, thus, increased risk of transmission to the infant.[9] For more details, see HIV-Infected Pregnant Women Who are Currently Receiving Antiretroviral Treatment.

Tenofovir has not demonstrated teratogenicity in rodents or monkeys. In infant monkeys with *in utero* exposure to tenofovir at maternal doses resulting in levels approximately 25 times those used in humans, low

birth weights and reductions in fetal bone porosity were seen. Chronic administration of tenofovir to immature animals of multiple species has resulted in reversible bone abnormalities; these effects were dose, exposure, age, and species specific. Data from the Antiretroviral Pregnancy Registry show a birth defect incidence of 2.3% in 1,370 women with first-trimester tenofovir exposure, similar to that in the general population.[6] An Italian study assessed growth patterns, bone health, and markers of bone metabolism in 33 infants with *in utero* exposure to tenofovir and found no difference compared with infants born to HIV-infected women who had not been exposed to tenofovir.[10] A larger study from the United States included 2,029 HIV-exposed but uninfected infants, 449 (21%) of whom had *in utero* exposure to tenofovir.[11] Although there were no differences in anthropomorphic parameters at birth, at age 1 year, infants exposed to tenofovir-based regimens had slight but significantly lower adjusted mean length and head circumference for age z-score than those without exposure to tenofovir. Because of the limited data on use in human pregnancy and concern regarding potential fetal bone effects and potential nephrotoxicity, tenofovir is recommended as an alternative rather than a preferred drug for use in pregnancy unless a pregnant woman is HIV/hepatitis B coinfected (see Table 5).

A modest but statistically significant increase in overall birth defect rates for didanosine and nelfinavir is observed when compared with the U.S. population-based Metropolitan Atlanta Congenital Defects Program (MACDP).[6] The lower bound of the CI for didanosine and nelfinavir (2.8%) is slightly above the higher bound (2.76%) for the MACDP rate. No specific pattern of defects has been detected with either didanosine or nelfinavir, and the clinical relevance of this statistical finding is unclear. The Registry will continue to monitor didanosine and nelfinavir for any signal or pattern of birth defects.

See Supplement: Safety and Toxicity of Individual Antiretroviral Drugs in Pregnancy to obtain detailed information on individual drugs.

Health care providers who are caring for HIV-infected pregnant women and their newborns are strongly advised to report instances of prenatal exposure to ARV drugs (either alone or in combination) to the Antiretroviral Pregnancy Registry. This registry is an epidemiologic project to collect observational, nonexperimental data regarding ARV exposure during pregnancy for the purpose of assessing the potential teratogenicity of these drugs. Registry data will be used to supplement animal toxicology studies and assist clinicians in weighing the potential risks and benefits of treatment for individual patients. The Antiretroviral Pregnancy Registry is a collaborative project of pharmaceutical manufacturers with an advisory committee of obstetric and pediatric practitioners. The registry does not use patient names, and registry staff obtain birth outcome follow-up information from the reporting physician.

Referrals should be directed to:

Antiretroviral Pregnancy Registry
Research Park
1011 Ashes Drive
Wilmington, NC 28405
Telephone: 1–800–258–4263
Fax: 1–800–800–1052
http://www.APRegistry.com

## References


1. Mills JL. Protecting the embryo from X-rated drugs. *N Engl J Med*. Jul 13 1995;333(2):124-125. Available at http://www.ncbi.nlm.nih.gov/pubmed/7777019.
2. Watts DH, Huang S, Culnane M, et al. Birth defects among a cohort of infants born to HIV-infected women on antiretroviral medication. *J Perinat Med*. Mar 2011;39(2):163-170. Available at

http://www.ncbi.nlm.nih.gov/pubmed/21142844.

3. Knapp KM, Brogly SB, Muenz DG, et al. Prevalence of congenital anomalies in infants with *in utero* exposure to antiretrovirals. *Pediatr Infect Dis J*. Feb 2012;31(2):164-170. Available at http://www.ncbi.nlm.nih.gov/pubmed/21983213.
4. Joao EC, Calvet GA, Krauss MR, et al. Maternal antiretroviral use during pregnancy and infant congenital anomalies: the NISDI perinatal study. *J Acquir Immune Defic Syndr.* Feb 2010;53(2):176-185. Available at http://www.ncbi.nlm.nih.gov/pubmed/20104119.
5. Bristol-Myers Squibb. Sustiva drug label, 11/30/2010. http://www.accessdata.fda.gov/drugsatfda_docs/label/2010/021360s024lbl.pdf. Accessed July 6, 2012.
6. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
7. Ford N, Mofenson L, Kranzer K, et al. Safety of efavirenz in first-trimester of pregnancy: a systematic review and meta-analysis of outcomes from observational cohorts. *AIDS*. Jun 19 2010;24(10):1461-1470. Available at http://www.ncbi.nlm.nih.gov/pubmed/20479637.
8. Ford N, Calmy A, Mofenson L. Safety of efavirenz in the first trimester of pregnancy: an updated systematic review and meta-analysis. *AIDS*. Nov 28 2011;25(18):2301-2304. Available at http://www.ncbi.nlm.nih.gov/pubmed/21918421.
9. Floridia M, Ravizza M, Pinnetti C, et al. Treatment change in pregnancy is a significant risk factor for detectable HIV-1 RNA in plasma at end of pregnancy. *HIV Clin Trials*. Nov-Dec 2010;11(6):303-311. Available at http://www.ncbi.nlm.nih.gov/pubmed/21239358.
10. Vigano A, Mora S, Giacomet V, et al. *In utero* exposure to tenofovir disoproxil fumarate does not impair growth and bone health in HIV-uninfected children born to HIV-infected mothers. *Antivir Ther*. 2011;16(8):1259-1266. Available at http://www.ncbi.nlm.nih.gov/pubmed/22155907.
11. Siberry GK, Williams PL, Mendez H, et al. Safety of tenofovir use during pregnancy: early growth outcomes in HIV-exposed uninfected infants. *AIDS*. Jun 1 2012;26(9):1151-1159. Available at http://www.ncbi.nlm.nih.gov/pubmed/22382151.

## Combination Antiretroviral Drug Regimens and Pregnancy Outcome (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendation |
|---|
| • Clinicians should be aware of a possible small increased risk of preterm birth in pregnant women receiving protease inhibitor (PI)-based combination antiretroviral regimens; however, given the clear benefits of such regimens for both a woman's health and prevention of mother-to-child transmission, PIs should not be withheld for fear of altering pregnancy outcome **(AII)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

Early data were conflicting as to whether receipt of combination antiretroviral (ARV) regimens during pregnancy is associated with adverse pregnancy outcomes and, in particular, preterm delivery. The European Collaborative Study and the Swiss Mother + Child HIV Cohort Study investigated the effects of combination ARV regimens in a population of 3,920 mother-child pairs. Adjusting for CD4 T-lymphocyte (CD4-cell) count and intravenous drug use, they found a roughly twofold increase in the odds of preterm delivery for infants exposed to combination regimens with or without protease inhibitors (PIs) compared with no drugs; women receiving combination regimens that had been initiated before pregnancy were twice as likely to deliver prematurely as those who started drugs during the third trimester.[1] However, PI-based combination regimens were received by only 108 (3%) of the women studied; confounding by severity or indication may have biased the results (that is, sicker women may have received PIs more often, but their advanced HIV infection may have actually caused the preterm births). Exposure to nucleoside reverse transcriptase inhibitor (NRTI) single-drug prophylaxis (primarily zidovudine) was not associated with prematurity.

An updated report from the European Collaborative Study, based on an adjusted analysis that included 2,279 mother-child pairs, found a 1.9-fold increased risk of delivery at less than 37 weeks with combination ARV regimens started during pregnancy and a 2.1-fold increased risk with combination ARV regimens started pre-pregnancy compared with mono- or dual-NRTI prophylaxis.[2] In this report, 767 women received combination ARV regimens during pregnancy, although the proportion receiving PIs was not specified. The risk of delivery before 34 weeks' gestation was increased by 2.5-fold for those starting combination ARV regimens during pregnancy and 4.4-fold for those entering pregnancy on combination ARV regimens.

In contrast, in an analysis of 7 prospective clinical studies that included 2,123 HIV-infected pregnant women who delivered infants between 1990 and 1998 and had received antenatal ARV regimens and 1,143 women who did not receive antenatal ARV drugs, the use of multiple ARV drugs compared with no drugs or treatment with 1 drug was not associated with increased rates of preterm birth, low birth weight, low Apgar scores, or stillbirth.[3] Nor were any significant associations between adverse pregnancy outcome and use of ARV drugs by class or by category (including combination ARV regimens) found in an analysis from the Women and Infants Transmission Study, including 2,543 HIV-infected women (some of whom were included in the previous meta-analysis).[4]

More recent data have continued to be conflicting as to whether preterm delivery is increased with combination ARV regimens. Table 7 reviews results from studies that have evaluated the association of ARV drug use during pregnancy and preterm delivery. Multiple studies have detected small but significant increases (odds ratio [OR] 1.2–1.8 in the largest studies) in preterm birth with PI- or non-PI-based combination ARV regimens

as well.[5-8] However, other recent studies that have controlled for maternal and pregnancy characteristics as well as factors related to HIV infection have shown no increase in adverse outcomes including preterm delivery and low birth weight in association with PI-containing drug regimens.[9-11] A meta-analysis of 14 European and American clinical studies found no increase in risk of preterm birth with either any ARV drug receipt compared with no drugs or combination ARV regimens including PIs compared with no drugs.[12] However, a significant but modest increased risk of preterm birth (OR 1.35; 95% confidence interval [CI], 1.08–1.70) was found in women who received combination regimens with PIs compared with combination regimens without PIs. Other reports have found increased rates of preterm birth when combination ARV regimens are compared with dual regimens[13] and when combination ARV regimens containing non-nucleoside reverse transcriptase inhibitors were compared with other combination ARV regimens.[14]

Other variables may confound these observational studies. Some studies have found increased rates of preterm birth if a combination ARV regimen is begun before conception or earlier in pregnancy compared with later during pregnancy, which itself may reflect confounding by severity or indication.[14, 15] Recent studies have assessed spontaneous preterm birth only, excluding delivery that was initiated at a preterm gestation because of medical or obstetrical reasons, and found no association between ARV and preterm birth.[16, 17] In an analysis of HIV-infected women enrolled in the ANRS French Perinatal Cohort from 1990 to 2009, preterm delivery rates were seen to increase over time, and preterm delivery was associated with combination ARV regimens versus either mono- or dual-ARV regimens and were highest in those who had initiated ARV before pregnancy.[18] A restricted analysis within this cohort of PI-based combination ARV regimens comparing boosted to unboosted PIs showed an association with induced preterm delivery for boosted PI regimens (adjusted odds ratio [AOR] 2.03; 95% CI, 2.06–3.89) that was not seen with spontaneous preterm birth. Boosted PI regimens were also associated with both medical and obstetrical complications, raising the possibility that the association with induced preterm delivery was mediated through these complications.

A secondary analyses of data collected during a randomized, controlled clinical trial conducted in Botswana in women with CD4 T-lymphocyte counts >200 cells/mm$^3$—267 randomized to receive lopinavir/ritonavir/zidovudine/lamivudine (PI group) and 263 randomized to receive abacavir/zidovudine/lamivudine (NRTI group) begun between 26 and 34 weeks' gestation for prevention of mother-to-child transmission and not for maternal health indications—did show an association between PI-containing ARV regimens and preterm delivery. In logistic regression analysis, use of combination PI-based ARV regimens was the most significant risk factor for preterm delivery (OR 2.03; 95% CI, 1.26–3.27).[19] Those receiving the latest initiation of ARV drugs had the highest preterm delivery rates. However the 20% background rate for preterm delivery in this population was not different from that seen in the PI group, and there was no difference between the 2 groups in neonatal morbidity and mortality. An observational study also from Botswana found that use of combination ARV regimens from before conception was not associated with very preterm delivery (AOR 0.78), which could not be assessed in the controlled clinical trial.[20]

Clinicians should be aware of a possible increased risk of preterm birth with use of combination ARV drug regimens; however, given the clear benefits for maternal health and reduction in perinatal transmission, these agents should not be withheld because of the possibility of increased risk of preterm delivery. Until more information is known, HIV-infected pregnant women who are receiving combination regimens for treatment of their HIV infection should continue their provider-recommended regimens. They should receive careful, regular monitoring for pregnancy complications and for potential toxicities.

**Table 7. Results of Studies Assessing Association Between Antiretroviral Regimens and Preterm Delivery (page 1 of 3)**

| Study Location(s)/ Dates of Study/ Reference | Total Number of Pregnancies/ Total on ARV Drugs | Types of ARV Regimens Compared (Numbers) | Association Noted Between PI-Containing or Other Multi-ARV Regimens and PTD | Special Notes |
|---|---|---|---|---|
| European Collaborative + Swiss Mother and Child HIV Cohort Study 1986–2000[1] | 3,920/896 | Mono (573)<br>Multi, no PI (215)<br>PI-multi (108) | YES (compared with no ARV)<br>Multi: 1.82 (1.13–2.92)<br>PI-multi: 2.60 (1.43–4.7) | • Increase in PTD if ARV begun before pregnancy versus in third trimester |
| United States 1990–1998[3] | 3,266/2,123 | Mono (1,590)<br>Multi (396)<br>PI-multi (137) | NO (compared with mono)<br>Multi: 0.95 (0.60–1.48)<br>PI-multi: 1.45 (0.81–2.50) | • 7 prospective clinical studies |
| European Collaborative Study 1986–2004[2] | 4,372/2,033 | Mono (704)<br>Dual (254)<br>Multi (1,075) | YES (compared with mono/dual)<br>Multi in pregnancy: 1.88 (1.34–2.65)<br>Multi prepregnancy: 2.05 (1.43–2.95) | |
| United States 1990–2002[4] | 2,543/not given | Early (<25 weeks):<br>Mono (621)<br>Multi (≥2 without PI or NNRTI) (198)<br>Multi (with PI or NNRTI) (357)<br>Late (≥32 weeks):<br>Mono (932)<br>Multi (≥2 without PI or NNRTI) (258)<br>Multi (with PI or NNRTI) (588) | NO (compared with mono)<br>No association between any ARV and PTD | • PTD decreased with ARV compared with no ARV |
| United States 1990–2002[21] | 1,337/999 | Mono (492)<br>Multi (373)<br>PI-multi (134) | YES (compared with other multi)<br>PI-multi: 1.8 (1.1–3.03) | • PI-multi reserved for advanced disease, those who failed other multi-ARV regimens |
| Brazil, Argentina, Mexico, Bahamas 2002–2005[22] | 681/681 | Mono/dual NRTI (94)<br>Multi-NNRTI (257)<br>Multi-PI (330) | NO (compared with mono/dual NRTI)<br>No association between any ARV regimen and PTD | • All on ARV for at least 28 days during pregnancy<br>• Preeclampsia/ eclampsia, cesarean delivery, diabetes, low BMI associated with PTD |

**Table 7. Results of Studies Assessing Association Between Antiretroviral Regimens and Preterm Delivery (page 2 of 3)**

| Study Location(s)/ Dates of Study/ Reference | Total Number of Pregnancies/ Total on ARV Drugs | Types of ARV Regimens Compared (Numbers) | Association Noted Between PI-Containing or Other Multi-ARV Regimens and PTD | Special Notes |
|---|---|---|---|---|
| Meta-analysis, Europe and United States 1986–2004[12] | 11,224/not given | Multi-no PI [including dual] or multi-PI (2,556) | YES (only comparing PI with multi)<br>PI versus multi no PI: 1.35 (1.08–1.70) | • 14 studies, 5 in PTD-ARV comparison<br>• No overall increase in PTD with antepartum ARV<br>• PTD increased in those on ARV pre-pregnancy and in first trimester compared with later use |
| Italy 2001–2006[7] | 419/366 | Multi-PI second trimester (97)<br>Multi-PI third trimester (146) | YES<br>Multi-PI second trimester: 2.24 (1.22–4.12)<br>Multi-PI third trimester: 2.81 (1.46–5.39) | • Multivariate association also with hepatitis C |
| United States 1989–2004[6] | 8,793/6,228 | Mono (2,621)<br>Dual (1,044)<br>Multi-no PI (1,781)<br>Multi-PI (782) | YES (compared with dual)<br>Multi-PI associated with PTD 1.21 (1.04–1.40) | • Lack of antepartum ARV also associated with PTD<br>• PTD and low birth weight decreased over time |
| United Kingdom, Ireland 1990–2005[5] | 5,009/4,445 | Mono/dual (1,061)<br>Multi-NNRTI or Multi-PI (3,384) | YES (compared with mono/dual)<br>Multi: 1.51 (1.19–1.93) | • Similar increased risk with PI or no-PI multi<br>• No association with duration of use |
| Germany, Austria 1995–2001[8] | 183/183 | Mono (77)<br>Dual (31)<br>Multi-PI (21)<br>Multi-NNRTI (54) | YES (compared with mono)<br>Multi-PI: 3.40 (1.13–10.2) | |
| United States 2002–2007[16] | 777/777 | Mono (6)<br>Dual (11)<br>Multi, no PI (202)<br>Multi-PI (558) | NO (compared PI with all non-PI)<br>Multi-PI: 1.22 (0.70–2.12) | • All started ARV during pregnancy<br>• Analyzed only spontaneous PTD |

**Table 7. Results of Studies Assessing Association Between Antiretroviral Regimens and Preterm Delivery (page 3 of 3)**

| Study Location(s)/ Dates of Study/ Reference | Total Number of Pregnancies/ Total on ARV Drugs | Types of ARV Regimens Compared (Numbers) | Association Noted Between PI-Containing or Other Multi-ARV Regimens and PTD | Special Notes |
|---|---|---|---|---|
| Swiss Mother and Child HIV Cohort Study 1985–2007[13] | 1,180/941 | Mono (94)<br>Dual (53)<br>Multi (PI or no PI) (409)<br>Multi-PI (385) | YES (compared with no ARV)<br>Multi: 2.5 (1.4–4.3) | • No association mono/dual with PTD compared with no ARV<br>• No confounding by duration of ARV or maternal risk factors |
| Botswana 2006–2008[19] | 530/530 | Lopinavir/ritonavir +zidovudine +lamivudine (267)<br>Abacavir +zidovudine +lamivudine (263) | YES<br>Multi-PI versus multi-NRTI: 2.03 (1.26–3.27) | • Secondary analysis of data from randomized, controlled clinical trial of ARV begun 26–34 weeks for MTCT prevention<br>• All CD4-cell counts >200 cells/mm$^3$ |
| Botswana 2007–2010[20] | 4,347/3,659 | ARV, regimen unspecified (70)<br>Mono (2,473)<br>Multi, 91% NNRTI (1,116) | NO<br>No association between multi-ART and very PTD (<32 weeks gestation) | • Observational multi-ART before conception associated with very small for gestational age and maternal hypertension during pregnancy |
| Spain 2000–2008[10] | 803/739 | Mono/dual (32)<br>Multi-no PI (281)<br>Multi-PI (426) | NO<br>No association between ARV and PTD | • Greatest PTD risk if no antepartum ARV received |
| Spain 1986–2010[17] | 519/371 | Mono/dual NRTI (73)<br>All multi (298)<br>Multi-PI (178) | NO (compared with no ARV + mono/dual)<br>• Spontaneous PTD not associated with multi-ARV or multi-PI before or during pregnancy | • Iatrogenic PTD associated with multi-ARV given in second half of pregnancy and prior PTD |

**Key to Abbreviations:** ARV = antiretroviral, BMI = body mass index, dual = two ARV drugs, mono = single ARV drug, MTCT = mother-to-child transmission, multi = three or more ARV drugs, multi-PI = combination ARV with PI, NNRTI = non-nucleoside analogue reverse transcriptase inhibitor, NRTI = nucleoside analogue reverse transcriptase inhibitor, PI = protease inhibitor, PTD = preterm delivery

## References


1. European Collaborative Study, Swiss Mother andChild HIV Cohort Study. Combination antiretroviral therapy and duration of pregnancy. *AIDS*. Dec 22 2000;14(18):2913-2920. Available at http://www.ncbi.nlm.nih.gov/pubmed/11398741.

2. Thorne C, Patel D, Newell ML. Increased risk of adverse pregnancy outcomes in HIV-infected women treated with highly active antiretroviral therapy in Europe. *AIDS*. Nov 19 2004;18(17):2337-2339. Available at http://www.ncbi.nlm.nih.gov/pubmed/15577551.

3. Tuomala RE, Shapiro DE, Mofenson LM, et al. Antiretroviral therapy during pregnancy and the risk of an adverse outcome. *N Engl J Med*. Jun 13 2002;346(24):1863-1870. Available at http://www.ncbi.nlm.nih.gov/pubmed/12063370.

4. Tuomala RE, Watts DH, Li D, et al. Improved obstetric outcomes and few maternal toxicities are associated with antiretroviral therapy, including highly active antiretroviral therapy during pregnancy. *J Acquir Immune Defic Syndr*. Apr 1 2005;38(4):449-473. Available at http://www.ncbi.nlm.nih.gov/pubmed/15764963.

5. Townsend CL, Cortina-Borja M, Peckham CS, Tookey PA. Antiretroviral therapy and premature delivery in diagnosed HIV-infected women in the United Kingdom and Ireland. *AIDS*. May 11 2007;21(8):1019-1026. Available at http://www.ncbi.nlm.nih.gov/pubmed/17457096.

6. Schulte J, Dominguez K, Sukalac T, Bohannon B, Fowler MG, Pediatric Spectrum of HIV Disease Consortium. Declines in low birth weight and preterm birth among infants who were born to HIV-infected women during an era of increased use of maternal antiretroviral drugs: Pediatric Spectrum of HIV Disease, 1989-2004. *Pediatrics*. Apr 2007;119(4):e900-906. Available at http://www.ncbi.nlm.nih.gov/pubmed/17353299.

7. Ravizza M, Martinelli P, Bucceri A, et al. Treatment with protease inhibitors and coinfection with hepatitis C virus are independent predictors of preterm delivery in HIV-infected pregnant women. *J Infect Dis*. Mar 15 2007;195(6):913-914; author reply 916-917. Available at http://www.ncbi.nlm.nih.gov/pubmed/17299723.

8. Grosch-Woerner I, Puch K, Maier RF, et al. Increased rate of prematurity associated with antenatal antiretroviral therapy in a German/Austrian cohort of HIV-1-infected women. *HIV Med*. Jan 2008;9(1):6-13. Available at http://www.ncbi.nlm.nih.gov/pubmed/18199167.

9. Dola CP, Khan R, Denicola N, et al. Combination antiretroviral therapy with protease inhibitors in HIV-infected pregnancy. *J Perinat Med*. Nov 2 2011. Available at http://www.ncbi.nlm.nih.gov/pubmed/22044007.

10. Gonzalez-Tome MI, Cuadrado I, et al. Risk factors of preterm delivery and low birth weight in a multicenter cohort of HIV-infected pregnant women. Paper presented at: 18th Conference on Retroviruses and Opportunistic Infections (CROI); February 27-March 2, 2011; Boston, MA. Abstract 744.

11. Beckerman K, Albano J, et al. Exposure to combination antritretoviral (cARV) regimens containing protease inhibitors (PI) during pregnancy and revalence of low birth weight/preterm delivery (LBS/PTD) among women with low pre-existing risk for LBW/PTD: a astratified analysis of 10,082 pregnancies. Paper presented at: 6th IAS Conference on HIV Pathogenesis and Treatment and Prevention; July 17-20, 2011; Rome, Italy.

12. Kourtis AP, Schmid CH, Jamieson DJ, Lau J. Use of antiretroviral therapy in pregnant HIV-infected women and the risk of premature delivery: a meta-analysis. *AIDS*. Mar 12 2007;21(5):607-615. Available at http://www.ncbi.nlm.nih.gov/pubmed/17314523.

13. Rudin C, Spaenhauer A, Keiser O, et al. Antiretroviral therapy during pregnancy and premature birth: analysis of Swiss data. *HIV Med*. Apr 2011;12(4):228-235. Available at http://www.ncbi.nlm.nih.gov/pubmed/20726902.

14. van der Merwe K, Hoffman R, Black V, Chersich M, Coovadia A, Rees H. Birth outcomes in South African women receiving highly active antiretroviral therapy: a retrospective observational study. *J Int AIDS Soc*. 2011;14:42. Available at http://www.ncbi.nlm.nih.gov/pubmed/21843356.

15. Machado ES, Hofer CB, Costa TT, et al. Pregnancy outcome in women infected with HIV-1 receiving combination antiretroviral therapy before versus after conception. *Sex Transm Infect*. Apr 2009;85(2):82-87. Available at http://www.ncbi.nlm.nih.gov/pubmed/18987014.

16. Patel K, Shapiro DE, Brogly SB, et al. Prenatal protease inhibitor use and risk of preterm birth among HIV-infected women initiating antiretroviral drugs during pregnancy. *J Infect Dis*. Apr 1 2010;201(7):1035-1044. Available at http://www.ncbi.nlm.nih.gov/pubmed/20196654.

17. Lopez M, Figueras F, Hernandez S, et al. Association of HIV infection with spontaneous and iatrogenic preterm delivery: effect of HAART. *AIDS*. Jan 2 2012;26(1):37-43. Available at http://www.ncbi.nlm.nih.gov/pubmed/22008651.

18. Sibiude J, Warszawski J, Tubiana R, et al. Premature delivery in HIV-infected women starting protease inhibitor therapy during pregnancy: role of the ritonavir boost? *Clin Infect Dis*. May 2012;54(9):1348-1360. Available at http://www.ncbi.nlm.nih.gov/pubmed/22460969.

19. Powis KM, Kitch D, Ogwu A, et al. Increased risk of preterm delivery among HIV-infected women randomized to protease versus nucleoside reverse transcriptase inhibitor-based HAART during pregnancy. *J Infect Dis*. Aug 15 2011;204(4):506-514. Available at http://www.ncbi.nlm.nih.gov/pubmed/21791651.

20. Parekh N, Ribaudo H, Souda S, et al. Risk factors for very preterm delivery and delivery of very-small-for-gestational-age infants among HIV-exposed and HIV-unexposed infants in Botswana. *Int J Gynaecol Obstet*. Oct 2011;115(1):20-25. Available at http://www.ncbi.nlm.nih.gov/pubmed/21767835.

21. Cotter AM, Garcia AG, Duthely ML, Luke B, O'Sullivan MJ. Is antiretroviral therapy during pregnancy associated with an increased risk of preterm delivery, low birth weight, or stillbirth? *J Infect Dis*. May 1 2006;193(9):1195-1201. Available at http://www.ncbi.nlm.nih.gov/pubmed/16586354.

22. Szyld EG, Warley EM, Freimanis L, et al. Maternal antiretroviral drugs during pregnancy and infant low birth weight and preterm birth. *AIDS*. Nov 28 2006;20(18):2345-2353. Available at http://www.ncbi.nlm.nih.gov/pubmed/17117021.

## Nevirapine and Hepatic/Rash Toxicity (Last updated September 14, 2011; last reviewed July 31, 2012)

| Panel's Recommendations |
|---|
| • Nevirapine-based regimens should be initiated in women with CD4 T-lymphocyte (CD4-cell) counts >250 cells/mm$^3$ only if the benefits clearly outweigh the risks because of the drug's potential for causing hepatic toxicity/hypersensitivity reaction **(AII)**. |
| • Women who become pregnant while receiving nevirapine-containing regimens and who are tolerating the regimen well can continue on the therapy regardless of CD4-cell count **(AII)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

Increases in hepatic transaminase levels (alanine aminotransferase [ALT] and aspartate aminotransferase [AST]) associated with rash or systemic symptoms may be observed during the first 18 weeks of treatment with nevirapine. Signs and symptoms of systemic toxicity may be nonspecific and can include fatigue, malaise, anorexia, nausea, jaundice, liver tenderness, or hepatomegaly with or without initially abnormal hepatic transaminases.[1] Development of severe nevirapine-associated skin rash has been reported to be 5.5 to 7.3 times more common in women than men and has been reported in pregnant women.[2, 3] Other studies have found that hepatic adverse events with systemic symptoms (predominantly rash) were 3.2-fold more common in women than in men.[4, 5] The degree of risk of rash and hepatic toxicity also appears to vary with CD4 T-lymphocyte (CD4-cell) count. In a summary analysis of data from 17 clinical trials of nevirapine therapy, women with CD4-cell counts >250 cells/mm$^3$ were 9.8 times more likely than women with lower CD4-cell counts to experience symptomatic, rash-associated, nevirapine-related hepatotoxicity;[4] a single-center study also found higher CD4-cell counts to be associated with increased risk of severe nevirapine-associated skin rash.[2] CD4-cell counts >250 cells/mm$^3$ predicted rash illness, but not liver enzyme elevation, among pregnant and non-pregnant women initiating nevirapine-based combination antiretroviral (ARV) regimens in three U.S. university clinics.[6] Other international cohorts of non-pregnant women have experienced hepatotoxicity and rash at similar rates as in U.S. studies, but not in association with CD4-cell counts >250 cells/mm$^3$.[7] In general, in controlled clinical trials, hepatic events, regardless of severity, have occurred in 4.0% (range 0%–11.0%) of patients who received nevirapine; severe or life-threatening rash has occurred in approximately 2% of patients receiving nevirapine.[8]

Several early reports of death due to hepatic failure in HIV-infected pregnant women receiving nevirapine as part of a combination ARV regimen raised concerns that pregnant women might be at increased risk of hepatotoxicity from nevirapine compared with other ARV drugs.[9, 10] Recent data challenge the notion that nevirapine is uniquely associated with increased hepatotoxicity during pregnancy.[11] In an analysis of two multicenter, prospective cohorts, pregnancy itself was a risk factor for liver enzyme elevations (relative risk 4.7; 5% confidence interval, 3.4–6.5), but nevirapine use was not, regardless of pregnancy status.[11] Additional data from the same cohorts did not show any increased risk of hepatotoxicity in HIV-infected pregnant women receiving nevirapine-based combination ARV regimens versus non-nevirapine-based combination ARV regimens.[12] These data suggest that nevirapine is no more toxic in pregnant women than in non-pregnant women. Nevertheless, if nevirapine is used in pregnancy, health care providers should be aware of potential hepatotoxicity with or without rash and should conduct frequent and careful monitoring of clinical symptoms and hepatic transaminases (that is, ALT and AST), particularly during the first 18 weeks of nevirapine use. Some clinicians measure serum transaminases at baseline, every 2 weeks for the first month,

monthly through Month 4, and every 1 to 3 months thereafter (see the Hepatotoxicity section of the table on Antiretroviral Therapy-Associated Common and/or Severe Adverse Effects in the *Guidelines for the Use of Antiretroviral Agents in HIV-1-Infected Adults and Adolescents*). In patients with pre-existing liver disease, monitoring should be performed more frequently when initiating nevirapine and monthly thereafter.[1] Transaminase levels should be checked in all women who develop a rash while receiving nevirapine. Patients who develop suggestive clinical symptoms accompanied by elevation in serum transaminase levels (ALT and/or AST) or who have asymptomatic but severe transaminase elevations (that is, more than 5 times the upper limit of normal) should stop nevirapine and not receive nevirapine again in the future.

Hepatic toxicity has not been seen in women receiving single-dose nevirapine during labor for prevention of perinatal transmission of HIV.[13] Women who enter pregnancy on nevirapine-containing regimens and are tolerating them well can continue therapy, regardless of CD4-cell count.

## References


1. Kontorinis N, Dieterich DT. Toxicity of non-nucleoside analogue reverse transcriptase inhibitors. *Semin Liver Dis*. May 2003;23(2):173-182. Available at http://www.ncbi.nlm.nih.gov/pubmed/12800070.
2. Bersoff-Matcha SJ, Miller WC, Aberg JA, et al. Sex differences in nevirapine rash. *Clin Infect Dis*. Jan 2001;32(1):124-129. Available at http://www.ncbi.nlm.nih.gov/pubmed/11118391.
3. Mazhude C, Jones S, Murad S, Taylor C, Easterbrook P. Female sex but not ethnicity is a strong predictor of non-nucleoside reverse transcriptase inhibitor-induced rash. *AIDS*. Jul 26 2002;16(11):1566-1568. Available at http://www.ncbi.nlm.nih.gov/pubmed/12131201.
4. Baylor MS, Johann-Liang R. Hepatotoxicity associated with nevirapine use. *J Acquir Immune Defic Syndr*. 2004;35(5):538-539. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=15021321.
5. Stern JO, Robinson PA, Love J, Lanes S, Imperiale MS, Mayers DL. A comprehensive hepatic safety analysis of nevirapine in different populations of HIV infected patients. *J Acquir Immune Defic Syndr*. Sep 2003;34(Suppl 1):S21-33. Available at http://www.ncbi.nlm.nih.gov/pubmed/14562855.
6. Aaron E, Kempf MC, Criniti S, et al. Adverse events in a cohort of HIV infected pregnant and non-pregnant women treated with nevirapine versus non-nevirapine antiretroviral medication. *PLoS One*. 2010;5(9):e12617. Available at http://www.ncbi.nlm.nih.gov/pubmed/20838641.
7. Peters PJ, Stringer J, McConnell MS, et al. Nevirapine-associated hepatotoxicity was not predicted by CD4 count ≥250 cells/muL among women in Zambia, Thailand and Kenya. *HIV Med*. Nov 2010;11(10):650-660. Available at http://www.ncbi.nlm.nih.gov/pubmed/20659176.
8. Boehringer-Ingelheim Pharmaceuticals Inc. Viramune drug label. March 25, 2011. Available at http://www.accessdata.fda.gov/drugsatfda_docs/label/2011/020933s028,020636s037lbl.pdf.
9. Lyons F, Hopkins S, Kelleher B, et al. Maternal hepatotoxicity with nevirapine as part of combination antiretroviral therapy in pregnancy. *HIV Med*. May 2006;7(4):255-260. Available at http://www.ncbi.nlm.nih.gov/pubmed/16630038.
10. Hitti J, Frenkel LM, Stek AM, et al. Maternal toxicity with continuous nevirapine in pregnancy: results from PACTG 1022. *J Acquir Immune Defic Syndr*. Jul 1 2004;36(3):772-776. Available at http://www.ncbi.nlm.nih.gov/pubmed/15213559.
11. Ouyang DW, Shapiro DE, Lu M, et al. Increased risk of hepatotoxicity in HIV-infected pregnant women receiving antiretroviral therapy independent of nevirapine exposure. *AIDS*. Nov 27 2009;23(18):2425-2430. Available at http://www.ncbi.nlm.nih.gov/pubmed/19617813.
12. Ouyang DW, Brogly SB, Lu M, et al. Lack of increased hepatotoxicity in HIV-infected pregnant women receiving nevirapine compared with other antiretrovirals. *AIDS*. Jan 2 2010;24(1):109-114. Available at http://www.ncbi.nlm.nih.gov/pubmed/19926957.

13. McKoy JM, Bennett CL, Scheetz MH, et al. Hepatotoxicity associated with long- versus short-course HIV-prophylactic nevirapine use: a systematic review and meta-analysis from the Research on Adverse Drug events And Reports (RADAR) project. *Drug Saf*. 2009;32(2):147-158. Available at http://www.ncbi.nlm.nih.gov/pubmed/19236121.

## Nucleoside Reverse Transcriptase Inhibitor Drugs and Mitochondrial Toxicity (Last updated July 31, 2012; last reviewed July 31, 2012)

**Panel's Recommendations**

- The combination of stavudine and didanosine should not be prescribed during pregnancy because of reports of lactic acidosis and maternal/neonatal mortality with prolonged use in pregnancy **(AII)**.
- Mitochondrial dysfunction should be considered in uninfected children with perinatal exposure to antiretroviral (ARV) drugs who present with severe clinical findings of unknown etiology, particularly neurologic findings **(AII)**.
- Long-term clinical follow-up is recommended for any child with *in utero* exposure to ARV drugs **(AIII)**.

***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*

***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion*

Nucleoside reverse transcriptase inhibitor (NRTI) drugs are known to induce mitochondrial dysfunction because the drugs have varying affinity for mitochondrial gamma DNA polymerase. This affinity can interfere with mitochondrial replication, resulting in mitochondrial DNA (mtDNA) depletion and dysfunction.[1] The relative potency of the NRTI drugs in inhibiting mitochondrial gamma DNA polymerase *in vitro* is highest for zalcitabine, followed by didanosine, stavudine, zidovudine, lamivudine, abacavir, and tenofovir.[2] In one study, didanosine and didanosine-containing regimens were associated with the greatest degree of mitochondrial suppression.[3] Toxicity related to mitochondrial dysfunction has been reported to occur in infected patients receiving long-term treatment with NRTI drugs and generally has resolved with discontinuation of the drug or drugs; a possible genetic susceptibility to these toxicities has been suggested.[1] These toxicities may be of particular concern for pregnant women and infants with *in utero* exposure to NRTI drugs.

Lactic acidosis with microvacuolar hepatic steatosis is a toxicity related to NRTI drugs that is thought to be related to mitochondrial toxicity; it has been reported to occur in infected individuals treated with NRTI drugs for longer than 6 months. In a report from the Food and Drug Administration Spontaneous Adverse Event Program, typical initial symptoms included 1 to 6 weeks of nausea, vomiting, abdominal pain, dyspnea, and weakness.[4] Metabolic acidosis with elevated serum lactate levels and elevated hepatic enzymes was common. Patients described in that report were predominantly female and overweight.

### *During Pregnancy*

Clinical disorders linked to mitochondrial toxicity include neuropathy, myopathy, cardiomyopathy, pancreatitis, hepatic steatosis, and lactic acidosis. Among these disorders, symptomatic lactic acidosis and hepatic steatosis may have a female preponderance.[5, 6] These syndromes have similarities to rare but life-threatening syndromes that occur during pregnancy, most often during the third trimester: acute fatty liver and hemolysis, elevated liver enzymes, and low platelets (HELLP) syndrome. Data suggest that a disorder of mitochondrial fatty acid oxidation in the mother or her fetus during late pregnancy may play a role in development of acute fatty liver of pregnancy and HELLP syndrome [7-10] and possibly contribute to susceptibility to antiretroviral (ARV)-associated mitochondrial toxicity. HELLP syndrome also can occur postpartum in women with severe preeclampsia.[11]

The frequency of this syndrome in pregnant HIV-infected women receiving NRTI drugs is unknown but a number of case reports of severe (1) or fatal (3) outcomes have been reported including several cases with

didanosine/stavudine used in combination during pregnancy. Nonfatal cases of lactic acidosis also have been reported in pregnant women receiving combination stavudine/didanosine.[12] Because of these reports of maternal mortality secondary to lactic acidosis with prolonged use of the combination of stavudine and didanosine by HIV-infected pregnant women, clinicians should not prescribe this ARV combination during pregnancy. Likewise, combination stavudine/didanosine also is not recommended for non-pregnant adults.

It is unclear if pregnancy augments the incidence of the lactic acidosis/hepatic steatosis syndrome that has been reported for non-pregnant individuals receiving NRTI drugs. However, because pregnancy itself can mimic some of the early symptoms of the lactic acidosis/hepatic steatosis syndrome or be associated with other disorders of liver metabolism, these cases emphasize the need for physicians caring for HIV-infected pregnant women receiving NRTI drugs to be alert for early signs of this syndrome.

In addition to low platelets and elevated liver enzymes, other laboratory findings reported in HIV-infected pregnant women on ARV drugs include depletion of mtDNA in the placenta but without evidence of ultrastructural damage to placental cells. The clinical significance of reduced mtDNA in placentas exposed to ARV drugs remains unknown.[13] A recent report by Hernandez et al. assessed mitochondrial and apoptotic parameters in mononuclear cells from maternal peripheral blood and infant cord blood from 27 HIV-infected and ARV-treated pregnant women and their infants and 35 uninfected controls and their infants.[14] Reduced newborn mtDNA levels, decreased maternal and fetal mitochondrial protein synthesis, and reduced maternal glycerol-3-phosphate and complex III function were observed in HIV- and ARV-exposed mothers and infants compared with uninfected controls. Maternal mtDNA depletion was particularly seen in HIV-infected pregnant women who had cumulative exposure to NRTIs of more than 100 months, suggesting NRTI-mediated injury. Also, Jitratkosol et al. reported increased prevalence of AG/TG mtDNA mutations among HIV-infected pregnant women receiving antiretroviral therapy.[15] However, no clinical adverse outcomes were linked to these findings in either pregnant women or their infants.

## In Utero *Exposure*

It has been suggested that mitochondrial dysfunction may develop in infants with *in utero* exposure to NRTI drugs. Data from a French cohort of 1,754 uninfected infants born to HIV-infected women who received ARV drugs during pregnancy identified 8 infants with *in utero* or neonatal exposure to either zidovudine/lamivudine (4) or zidovudine alone (4) who developed indications of mitochondrial dysfunction after the first few months of life.[16] Two of these infants (both exposed to zidovudine/lamivudine) contracted severe neurologic disease and died; 3 had mild-to-moderate symptoms; and 3 had no symptoms but had transient laboratory abnormalities.

In a larger cohort of 4,392 uninfected children (including the children in the previous study) followed within the French Pediatric Cohort or identified within a French National Register, the 18-month incidence of clinical symptoms of mitochondrial dysfunction was 0.26% and 0.07% for mortality.[17] All children had perinatal exposure to ARV drugs; risk was higher among infants exposed to combination ARV drugs (primarily zidovudine/lamivudine) than to zidovudine alone. The children presented with neurologic symptoms, often with abnormal magnetic resonance imaging and/or episodes of significant hyperlactatemia, and deficits in mitochondrial respiratory chain complex enzyme function on biopsy of muscle. The same group also has reported an increased risk of simple febrile seizures in the first 18 months of life and persistently lower (but clinically insignificant) neutrophil, lymphocyte, and platelet counts in infants with *in utero* exposure to NRTIs.[18, 19] More recently, in continued follow-up of the French Perinatal Cohort, researchers reported severe neurologic symptoms in the first 2 years of life as a rare event (0.3%–0.5%).[20]

Other clinical studies from the United States and Europe generally have not duplicated the French reports.[21-27] The Perinatal Safety Review Working Group performed a retrospective review of deaths occurring in children born to HIV-infected women and followed from 1986 to 1999 in 5 large, prospective U.S. perinatal

cohorts. No deaths similar to those reported from France or with clinical findings attributable to mitochondrial dysfunction were identified in a database of more than 16,000 uninfected children born to HIV-infected women with and without exposure to ARV drugs.[22] However, most of the infants with exposure to ARVs had been exposed to zidovudine alone and only a relatively small proportion (approximately 6%) had been exposed to zidovudine/lamivudine.

The European Collaborative Study reviewed clinical symptoms in 2,414 uninfected children in their cohort with median follow-up of 2.2 years (maximum, 16 years); 1,008 had perinatal exposure to ARV drugs.[24] No association was found between clinical manifestations suggestive of mitochondrial abnormalities and perinatal exposure to ARV drugs. Of the 4 children with seizures in this cohort, none had perinatal exposure to ARV drugs. In a report from a long-term follow-up study in the United States (PACTG 219/219C), 20 children with possible symptoms of mitochondrial dysfunction were identified in a cohort of 1,037 uninfected infants born to HIV-infected mothers.[26] Definitive diagnosis was not available because none of the children had biopsies for mitochondrial function. Three of the 20 children had no exposure to ARV drugs. In the 17 remaining children, although overall exposure to NRTIs was not associated with symptoms, there was an association between symptoms and first exposure to zidovudine/lamivudine limited to the third trimester. Some small alterations in mtDNA and oxidative phosphorylation enzyme activities were found in stored specimens from these children, but the clinical significance of these observations remains unknown.[28, 29]

Laboratory abnormalities without clinical symptoms have been reported in infants with perinatal exposure to ARV drugs compared with unexposed infants in a number of studies, most of which are limited by small numbers of subjects. In one study, mtDNA quantity was lower in cord and peripheral blood white cells at ages 1 and 2 years in 20 infants born to HIV-infected women compared with 30 infants born to uninfected women and was lowest in 10 HIV-exposed infants with zidovudine exposure compared with 10 without zidovudine exposure.[30] In a subsequent study, mitochondrial changes were evaluated in umbilical cord endothelial cells and cord blood from human infants and monkeys with *in utero* exposure to various NRTI-containing regimens.[31] Similar morphologic changes and mtDNA depletion were seen in the human and monkey infants. In the monkey study, mitochondrial damage demonstrated a gradient, with greatest damage with stavudine/lamivudine > zidovudine/didanosine > zidovudine/lamivudine > lamivudine. In a Canadian study of 73 ARV-exposed infants and 81 controls with blood samples during the first 8 months of life, investigators found that in the first weeks of life, blood mtDNA levels were higher and blood mitochondrial RNA levels were lower in the HIV- and ARV-exposed infants compared with infants without HIV and ARV exposure.[32]

Aldrovandi et al. reported that peripheral blood mononuclear cell mtDNA levels were lower at birth in HIV-exposed, ARV-exposed infants compared with non-HIV, non-ARV-exposed infants.[33] However, among the HIV-exposed infants, those with combination ARV drug exposure *in utero* had higher mtDNA levels than those exposed only to zidovudine *in utero*. Umbilical cord mtDNA sequence variants were 3-fold higher among HIV- and zidovudine-exposed infants compared with infants born to HIV-uninfected mothers.[34] Most recently, Jitratkosol reported blood mtDNA mutations in HIV-exposed infants and Hernandez et al. reported subclinical mitochondrial dysfunction with decreased mtDNA levels and mtDNA protein synthesis.[14, 15]

*Other laboratory findings among HIV-exposed infants:*

Transient hyperlactatemia during the first few weeks of life was reported in 17 HIV-exposed infants with perinatal exposure to ARV drugs; lactate levels returned to normal in all children and none developed symptoms of mitochondrial dysfunction during follow-up.[35] Similarly, the French Perinatal Cohort Study has reported asymptomatic hyperlactatemia in one-third of zidovudine-exposed newborns, which resolved following perinatal exposure to the drug.[20] Clinically asymptomatic hematologic findings have been reported by several investigators in uninfected infants with *in utero* exposure to ARV regimens in the United States and Europe,[36-38] and infants with exposure to triple-combination ARV regimens were found to be at increased risk of lowered hemoglobin compared with those with perinatal exposure to zidovudine or

zidovudine/lamivudine.[39] Similar hematologic findings of anemia have also been reported in a Botswana study. Dryden-Peterson et al. reported that 12.5% of breastfed infants of mothers on ARV drugs during pregnancy and during breastfeeding in Botswana experienced at least 1 episode of Grade 3 or Grade 4 reduced hemoglobin by age 6 months compared with 5.3% of breastfed infants exposed to zidovudine *in utero* followed by daily infant zidovudine for 6 months and 2.5% of infants who were exposed to the drug *in utero* and for 1 month post-birth and were formula fed.[40] The Botswana study group has also reported decreased birth weight and decreased weight for age and length for age in the first several months of life in infants exposed to ARV drugs.

Echocardiographic abnormalities have been reported among 136 ARV drug- and HIV-exposed uninfected infants compared with 216 HIV-exposed, uninfected infants without ARV drug exposure in the NHLBI CHAART-1 study.[41] In infants up to age 2 years, prenatal ARV exposure was associated with reduced left ventricular mass, dimension, and septal wall thickness z-scores and increased left ventricular fractional shortening and contractility compared with lack of ARV drug exposure. These findings were more prominent in female than in male infants.

The clinical significance of these differences in mtDNA, lactate levels, and hematologic and cardiac laboratory findings remains unclear. Further long-term studies are needed to validate the findings and assess whether they affect long-term growth and development of infants exposed to ARV drugs. Even if an association is more clearly demonstrated, the development of severe or fatal mitochondrial disease appears to be extremely rare and must be balanced against the proven benefit of ARV prophylaxis in significantly reducing transmission of HIV from mothers to their infants.[24, 42, 43]

Development of new diagnostic techniques, including use of flow cytometry assays to screen for mitochondrial function, may lead to more accurate assessment of mitochondrial toxicity.[44] Mitochondrial dysfunction should be considered in uninfected children with perinatal exposure to ARV drugs who present with severe clinical findings of unknown etiology, particularly neurologic findings. Current recommendations emphasize the need for long-term clinical follow-up for any child with *in utero*, peripartum, or postnatal exposure to ARV drugs used for prevention of mother-to-child transmission.

## References


1. Brinkman K, Ter Hofstede HJM, Burger DM, et al. Adverse effects of reverse transcriptase inhibitors: mitochondrial toxicity as common pathway. *AIDS*. 1998;12(14):1735-1744. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=9792373&dopt=Abstract.
2. Birkus G, Hitchcock MJ, Cihlar T. Assessment of mitochondrial toxicity in human cells treated with tenofovir: comparison with other nucleoside reverse transcriptase inhibitors. *Antimicrob Agents Chemother*. Mar 2002;46(3):716-723. Available at http://www.ncbi.nlm.nih.gov/pubmed/11850253.
3. Saitoh A, Haas RH, Naviaux RK, Salva NG, Wong JK, Spector SA. Impact of nucleoside reverse transcriptase inhibitors on mitochondrial DNA and RNA in human skeletal muscle cells. *Antimicrob Agents Chemother.* Aug 2008;52(8):2825-2830. Available at http://www.ncbi.nlm.nih.gov/pubmed/18541728.
4. Fleischer R, Boxwell D, Sherman KE. Nucleoside analogues and mitochondrial toxicity. *Clin Infect Dis*. Apr 15 2004;38(8):e79-80. Available at http://www.ncbi.nlm.nih.gov/pubmed/15095236.
5. Currier JS. Sex differences in antiretroviral therapy toxicity: lactic acidosis, stavudine, and women. *Clin Infect Dis*. Jul 15 2007;45(2):261-262. Available at http://www.ncbi.nlm.nih.gov/pubmed/17578789.
6. Bolhaar MG, Karstaedt AS. A high incidence of lactic acidosis and symptomatic hyperlactatemia in women receiving highly active antiretroviral therapy in Soweto, South Africa. *Clin Infect Dis*. Jul 15 2007;45(2):254-260. Available at http://www.ncbi.nlm.nih.gov/pubmed/17578788.

7. Ibdah JA, Bennett MJ, Rinaldo P, et al. A fetal fatty-acid oxidation disorder as a cause of liver disease in pregnant women. *N Engl J Med*. Jun 3 1999;340(22):1723-1731. Available at http://www.ncbi.nlm.nih.gov/pubmed/10352164.

8. Strauss AW, Bennett MJ, Rinaldo P, et al. Inherited long-chain 3-hydroxyacyl-CoA dehydrogenase deficiency and a fetal-maternal interaction cause maternal liver disease and other pregnancy complications. *Semin Perinatol*. Apr 1999;23(2):100-112. Available at http://www.ncbi.nlm.nih.gov/pubmed/10331463.

9. Sims HF, Brackett JC, Powell CK, et al. The molecular basis of pediatric long chain 3-hydroxyacyl-CoA dehydrogenase deficiency associated with maternal acute fatty liver of pregnancy. *Proc Natl Acad Sci U S A*. Jan 31 1995;92(3):841-845. Available at http://www.ncbi.nlm.nih.gov/pubmed/7846063.

10. Ibdah JA, Yang Z, Bennett MJ. Liver disease in pregnancy and fetal fatty acid oxidation defects. *Mol Genet Metab*. Sep-Oct 2000;71(1-2):182-189. Available at http://www.ncbi.nlm.nih.gov/pubmed/11001809.

11. Gasem T, Al Jama FE, Burshaid S, Rahman J, Al Suleiman SA, Rahman MS. Maternal and fetal outcome of pregnancy complicated by HELLP syndrome. *J Matern Fetal Neonatal Med*. Dec 2009;22(12):1140-1143. Available at http://www.ncbi.nlm.nih.gov/pubmed/19916711.

12. Mandelbrot L, Kermarrec N, Marcollet A, et al. Case report: nucleoside analogue-induced lactic acidosis in the third trimester of pregnancy. *AIDS*. Jan 24 2003;17(2):272-273. Available at http://www.ncbi.nlm.nih.gov/pubmed/12545093.

13. Gingelmaier A, Grubert TA, Kost BP, et al. Mitochondrial toxicity in HIV type-1-exposed pregnancies in the era of highly active antiretroviral therapy. *Antivir Ther.* 2009;14(3):331-338. Available at http://www.ncbi.nlm.nih.gov/pubmed/19474467.

14. Hernandez S, Moren C, Lopez M, et al. Perinatal outcomes, mitochondrial toxicity and apoptosis in HIV-treated pregnant women and in-utero-exposed newborn. *AIDS*. Feb 20 2012;26(4):419-428. Available at http://www.ncbi.nlm.nih.gov/pubmed/22156962.

15. Jitratkosol MH, Sattha B, Maan EJ, et al. Blood mitochondrial DNA mutations in HIV-infected women and their infants exposed to HAART during pregnancy. *AIDS*. Mar 27 2012;26(6):675-683. Available at http://www.ncbi.nlm.nih.gov/pubmed/22436539.

16. Blanche S, Tardieu M, Rustin P, et al. Persistent mitochondrial dysfunction and perinatal exposure to antiretroviral nucleoside analogues. *Lancet*. Sep 25 1999;354(9184):1084-1089. Available at http://www.ncbi.nlm.nih.gov/pubmed/10509500.

17. Barret B, Tardieu M, Rustin P, et al. Persistent mitochondrial dysfunction in HIV-1-exposed but uninfected infants: clinical screening in a large prospective cohort. *AIDS*. Aug 15 2003;17(12):1769-1785. Available at http://www.ncbi.nlm.nih.gov/pubmed/12891063.

18. Landreau-Mascaro A, Barret B, Mayaux MJ, Tardieu M, Blanche S, French Perinatal Cohort Study Group. Risk of early febrile seizure with perinatal exposure to nucleoside analogues. *Lancet*. Feb 16 2002;359(9306):583-584. Available at http://www.ncbi.nlm.nih.gov/pubmed/11867117.

19. Le Chenadec J, Mayaux MJ, Guihenneuc-Jouyaux C, Blanche S, Enquete Perinatale Francaise Study Group. Perinatal antiretroviral treatment and hematopoiesis in HIV-uninfected infants. *AIDS*. Sep 26 2003;17(14):2053-2061. Available at http://www.ncbi.nlm.nih.gov/pubmed/14502008.

20. Benhammou V, Tardieu M, Warszawski J, Rustin P, Blanche S. Clinical mitochondrial dysfunction in uninfected children born to HIV-infected mothers following perinatal exposure to nucleoside analogues. *Environ Mol Mutagen*. Apr-May 2007;48(3-4):173-178. Available at http://www.ncbi.nlm.nih.gov/pubmed/17358031.

21. Sperling RS, Shapiro DE, McSherry GD, et al. Safety of the maternal-infant zidovudine regimen utilized in the Pediatric AIDS Clinical Trial Group 076 Study. *AIDS*. Oct 1 1998;12(14):1805-1813. Available at http://www.ncbi.nlm.nih.gov/pubmed/9792381.

22. The Perinatal Safety Review Working Group. Nucleoside exposure in the children of HIV-infected women receiving antiretroviral drugs: absence of clear evidence for mitochondrial disease in children who died before 5 years of age in five United States cohorts. *J Acquir Immune Defic Syndr*. Nov 1 2000;25(3):261-268. Available at

http://www.ncbi.nlm.nih.gov/pubmed/11115957.

23. Lipshultz SE, Easley KA, Orav EJ, et al. Absence of cardiac toxicity of zidovudine in infants. Pediatric Pulmonary and Cardiac Complications of Vertically Transmitted HIV Infection Study Group. *N Engl J Med*. Sep 14 2000;343(11):759-766. Available at http://www.ncbi.nlm.nih.gov/pubmed/10984563.

24. European Collaborative Study. Exposure to antiretroviral therapy *in utero* or early life: the health of uninfected children born to HIV-infected women. *J Acquir Immune Defic Syndr*. 2003;32(4):380-387. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=12640195&dopt=Abstract.

25. Alimenti A, Forbes JC, Oberlander TF, et al. A prospective controlled study of neurodevelopment in HIV-uninfected children exposed to combination antiretroviral drugs in pregnancy. *Pediatrics*. Oct 2006;118(4):e1139-1145. Available at http://www.ncbi.nlm.nih.gov/pubmed/16940166.

26. Brogly SB, Ylitalo N, Mofenson LM, et al. *In utero* nucleoside reverse transcriptase inhibitor exposure and signs of possible mitochondrial dysfunction in HIV-uninfected children. *AIDS*. May 11 2007;21(8):929-938. Available at http://www.ncbi.nlm.nih.gov/pubmed/17457086.

27. Hankin C, Lyall H, Peckham C, Tookey P. Monitoring death and cancer in children born to HIV-infected women in England and Wales: use of HIV surveillance and national routine data. *AIDS*. Apr 23 2007;21(7):867-869. Available at http://www.ncbi.nlm.nih.gov/pubmed/17415042.

28. Brogly SB, DiMauro S, Van Dyke RB, et al. Short communication: transplacental nucleoside analogue exposure and mitochondrial parameters in HIV-uninfected children. *AIDS Res Hum Retroviruses*. Jul 2011;27(7):777-783. Available at http://www.ncbi.nlm.nih.gov/pubmed/21142587.

29. Brogly SB, Foca M, Deville JG, et al. Potential confounding of the association between exposure to nucleoside analogues and mitochondrial dysfunction in HIV-uninfected and indeterminate infants. *J Acquir Immune Defic Syndr*. Jan 2010;53(1):154-157. Available at http://www.ncbi.nlm.nih.gov/pubmed/20035168.

30. Poirier MC, Divi RL, Al-Harthi L, et al. Long-term mitochondrial toxicity in HIV-uninfected infants born to HIV-infected mothers. *J Acquir Immune Defic Syndr*. Jun 1 2003;33(2):175-183. Available at http://www.ncbi.nlm.nih.gov/pubmed/12794551.

31. Divi RL, Leonard SL, Kuo MM, et al. Transplacentally exposed human and monkey newborn infants show similar evidence of nucleoside reverse transcriptase inhibitor-induced mitochondrial toxicity. *Environ Mol Mutagen*. Apr-May 2007;48(3-4):201-209. Available at http://www.ncbi.nlm.nih.gov/pubmed/16538687.

32. Cote HC, Raboud J, Bitnun A, et al. Perinatal exposure to antiretroviral therapy is associated with increased blood mitochondrial DNA levels and decreased mitochondrial gene expression in infants. *J Infect Dis*. Sep 15 2008;198(6):851-859. Available at http://www.ncbi.nlm.nih.gov/pubmed/18684095.

33. Aldrovandi GM, Chu C, Shearer WT, et al. Antiretroviral exposure and lymphocyte mtDNA content among uninfected infants of HIV-1-infected women. *Pediatrics*. Dec 2009;124(6):e1189-1197. Available at http://www.ncbi.nlm.nih.gov/pubmed/19933732.

34. Torres SM, Walker DM, McCash CL, et al. Mutational analysis of the mitochondrial tRNA genes and flanking regions in umbilical cord tissue from uninfected infants receiving AZT-based therapies for prophylaxis of HIV-1. *Environ Mol Mutagen*. Jan 2009;50(1):10-26. Available at http://www.ncbi.nlm.nih.gov/pubmed/19031409.

35. Giaquinto C, De Romeo A, Giacomet V, et al. Lactic acid levels in children perinatally treated with antiretroviral agents to prevent HIV transmission. *AIDS*. May 25 2001;15(8):1074-1075. Available at http://www.ncbi.nlm.nih.gov/pubmed/11399997.

36. Pacheco SE, McIntosh K, Lu M, et al. Effect of perinatal antiretroviral drug exposure on hematologic values in HIV-uninfected children: An analysis of the women and infants transmission study. *J Infect Dis*. Oct 15 2006;194(8):1089-1097. Available at http://www.ncbi.nlm.nih.gov/pubmed/16991083.

37. European Collaborative Study. Levels and patterns of neutrophil cell counts over the first 8 years of life in children of HIV-1-infected mothers. *AIDS*. Oct 21 2004;18(15):2009-2017. Available at

http://www.ncbi.nlm.nih.gov/pubmed/15577622.

38. Bunders M, Thorne C, Newell ML, European Collaborative Study. Maternal and infant factors and lymphocyte, CD4 and CD8 cell counts in uninfected children of HIV-1-infected mothers. *AIDS*. Jul 1 2005;19(10):1071-1079. Available at http://www.ncbi.nlm.nih.gov/pubmed/15958839.

39. Feiterna-Sperling C, Weizsaecker K, Buhrer C, et al. Hematologic effects of maternal antiretroviral therapy and transmission prophylaxis in HIV-1-exposed uninfected newborn infants. *J Acquir Immune Defic Syndr*. May 1 2007;45(1):43-51. Available at http://www.ncbi.nlm.nih.gov/pubmed/17356471.

40. Dryden-Peterson S, Shapiro RL, Hughes MD, et al. Increased risk of severe infant anemia after exposure to maternal HAART, Botswana. *J Acquir Immune Defic Syndr*. Apr 15 2011;56(5):428-436. Available at http://www.ncbi.nlm.nih.gov/pubmed/21266910.

41. Lipshultz SE, Shearer WT, Thompson B, et al. Cardiac effects of antiretroviral therapy in HIV-negative infants born to HIV-positive mothers: NHLBI CHAART-1 (National Heart, Lung, and Blood Institute Cardiovascular Status of HAART Therapy in HIV-Exposed Infants and Children cohort study). *J Am Coll Cardiol*. Jan 4 2011;57(1):76-85. Available at http://www.ncbi.nlm.nih.gov/pubmed/21185505.

42. Morris AA, Carr A. HIV nucleoside analogues: new adverse effects on mitochondria? *Lancet*. Sep 25 1999;354(9184):1046-1047. Available at http://www.ncbi.nlm.nih.gov/pubmed/10509488.

43. Cooper ER, Charurat M, Mofenson L, et al. Combination antiretroviral strategies for the treatment of pregnant HIV-1-infected women and prevention of perinatal HIV-1 transmission. *J Acquir Immune Defic Syndr*. Apr 15 2002;29(5):484-494. Available at http://www.ncbi.nlm.nih.gov/pubmed/11981365.

44. Lin CH, Sloan DD, Dang CH, et al. Assessment of mitochondrial toxicity by analysis of mitochondrial protein expression in mononuclear cells. *Cytometry B Clin Cytom*. May 2009;76(3):181-190. Available at http://www.ncbi.nlm.nih.gov/pubmed/18823003.

## Protease Inhibitor Therapy and Hyperglycemia (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendation |
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| • HIV-infected women taking antiretroviral drug regimens during pregnancy should undergo standard glucose screening at 24 to 28 weeks' gestation **(AIII)**. Some experts would perform earlier glucose screening in women receiving ongoing protease inhibitor-based regimens initiated before pregnancy, similar to recommendations for women with high risk factors for glucose intolerance **(BIII)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

Hyperglycemia, new-onset diabetes mellitus, exacerbation of existing diabetes mellitus, and diabetic ketoacidosis have been reported in HIV-infected patients taking protease inhibitors (PIs).[1-4] In addition, pregnancy is itself a risk factor for hyperglycemia. To date, however, the majority of studies have not shown an increased risk of glucose intolerance with PI-based regimens during pregnancy. One small retrospective study that included 41 women receiving PI-based combination antiretroviral (ARV) regimens found an increased risk of glucose intolerance, but not gestational diabetes, among women on combination ARV regimens compared with zidovudine alone,[5] although 2 other retrospective studies did not find an increased risk of glucose intolerance with PIs.[6, 7] Secondary analyses of 2 large cohorts did not find an association between the type of ARV regimen and gestational diabetes, except for an association between initiation of PIs before pregnancy or during the first trimester and gestational diabetes in the PACTG 316 cohort.[8, 9] Finally, a prospective study including detailed evaluations for glucose intolerance and insulin resistance among HIV-infected pregnant women did not find differences between women on PI-containing and non-PI-containing regimens.[10] In both groups, however, the rate of impaired glucose tolerance was high (38%), likely related to high body mass index and race/ethnicity among trial subjects.

HIV-infected women receiving ARV regimens during pregnancy should receive standard glucose screening at 24 to 28 weeks' gestation. Some experts would perform earlier glucose screening in women with ongoing PI-based ARV regimens initiated before pregnancy (particularly those of minority race/ethnicity), similar to recommendations for women with high risk factors for glucose intolerance, such as maternal obesity, advanced maternal age, and family history of type II diabetes mellitus.

## References


1. Food and Drug Administration. FDA Public Health Advisory: reports of diabetes and hyperglycemia in patients receiving protease inhibitors for treatment of human immunodeficiency virus (HIV). Food and Drug Administration, Public Health Service, Department of Health and Human Services. Rockville, MD: June 11, 1997. Available at http://www.fda.gov/cder/news/proteaseletter.htm.
2. Visnegarwala F, Krause KL, Musher DM. Severe diabetes associated with protease inhibitor therapy. *Ann Intern Med*. Nov 15 1997;127(10):947. Available at http://www.ncbi.nlm.nih.gov/pubmed/9382374.
3. Eastone JA, Decker CF. New-onset diabetes mellitus associated with use of protease inhibitor. *Ann Intern Med*. Nov 15 1997;127(10):948. Available at http://www.ncbi.nlm.nih.gov/pubmed/9382376.
4. Dube MP, Sattler FR. Metabolic complications of antiretroviral therapies. *AIDS Clin Care*. Jun 1998;10(6):41-44.

Available at http://www.ncbi.nlm.nih.gov/pubmed/11365497.

5. Chmait R, Franklin P, Spector SA, Hull AD. Protease inhibitors and decreased birth weight in HIV-infected pregnant women with impaired glucose tolerance. *J Perinatol*. Jul-Aug 2002;22(5):370-373. Available at http://www.ncbi.nlm.nih.gov/pubmed/12082471.
6. Dinsmoor MJ, Forrest ST. Lack of an effect of protease inhibitor use on glucose tolerance during pregnancy. *Infect Dis Obstet Gynecol*. 2002;10(4):187-191. Available at http://www.ncbi.nlm.nih.gov/pubmed/12648312.
7. Tang JH, Sheffield JS, Grimes J, et al. Effect of protease inhibitor therapy on glucose intolerance in pregnancy. *Obstet Gynecol*. May 2006;107(5):1115-1119. Available at http://www.ncbi.nlm.nih.gov/pubmed/16648418.
8. Tuomala RE, Watts DH, Li D, et al. Improved obstetric outcomes and few maternal toxicities are associated with antiretroviral therapy, including highly active antiretroviral therapy during pregnancy. *J Acquir Immune Defic Syndr*. Apr 1 2005;38(4):449-473. Available at http://www.ncbi.nlm.nih.gov/pubmed/15764963.
9. Watts DH, Balasubramanian R, Maupin RT, Jr., et al. Maternal toxicity and pregnancy complications in human immunodeficiency virus-infected women receiving antiretroviral therapy: PACTG 316. *Am J Obstet Gynecol*. Feb 2004;190(2):506-516. Available at http://www.ncbi.nlm.nih.gov/pubmed/14981398.
10. Hitti J, Andersen J, McComsey G, et al. Protease inhibitor-based antiretroviral therapy and glucose tolerance in pregnancy: AIDS Clinical Trials Group A5084. *Am J Obstet Gynecol*. Apr 2007;196(4):331 e331-337. Available at http://www.ncbi.nlm.nih.gov/pubmed/17403409.

# Antiretroviral Drug Resistance and Resistance Testing in Pregnancy (Last updated July 31, 2012; last reviewed July 31, 2012)

**Panel's Recommendations**

- HIV drug-resistance studies should be performed before starting or modifying antiretroviral (ARV) regimens in all pregnant women whose HIV RNA levels are above the threshold for resistance testing (that is >500–1,000 copies/mL) before initiation of ARVs **(AIII)** and for those entering pregnancy with detectable HIV RNA levels while receiving antiretroviral therapy or who have suboptimal viral suppression after starting ARVs during pregnancy **(AII)**.
- In women who present late in pregnancy, an empiric ARV regimen should be initiated promptly without waiting for the results of resistance testing, with adjustment as needed after test results are available, for optimal prevention of perinatal transmission and maternal health **(BIII)**.
- Women who have documented zidovudine resistance and are on regimens that do not include zidovudine for their own health should still receive intravenous zidovudine during labor along with their established ARV regimens if they have HIV RNA levels >400 copies/mL near delivery (see Intrapartum Antiretroviral Prophylaxis/Therapy), unless a history of hypersensitivity is documented **(AII)**.
- The optimal prophylactic regimen for newborns of women with ARV resistance is unknown (see Infant Antiretroviral Prophylaxis). Therefore, ARV prophylaxis for an infant born to a woman with known or suspected drug resistance should be determined in consultation with a pediatric HIV specialist, preferably before delivery (see Infant Antiretroviral Prophylaxis) **(AIII)**.
- HIV-infected pregnant women should be given combination ARV drug regimens to maximally suppress viral replication, which is the most effective strategy for preventing development of resistance and minimizing risk of perinatal transmission **(AII)**.
- All pregnant and postpartum women should be counseled about the importance of adherence to prescribed ARV medications to reduce the potential for development of resistance **(AII)**.
- To minimize development of resistance, pregnant women who receive a non-nucleoside reverse transcriptase inhibitor (NNRTI)-based combination ARV regimen that is discontinued after delivery should receive either dual nucleoside analogue reverse transcriptase agents alone **(AI)** or with a protease inhibitor **(BII)** for 7 to 30 days **(AII)** after stopping the NNRTI drug. The optimal interval between stopping an NNRTI and the other ARV drugs is unknown (see Stopping Antiretroviral Therapy during Pregnancy and Postpartum Follow-Up of HIV-Infected Women).

***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*

***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion*

## Indications for Antiretroviral Drug-Resistance Testing in HIV-Infected Pregnant Women

In addition to a comprehensive history of antiretroviral (ARV) drug use, genotypic resistance testing is recommended for all ARV-naive pregnant women with HIV RNA levels above the threshold for resistance testing (e.g., >500–1,000 copies/mL) before initiating antiretroviral treatment (ART) or prophylaxis. For details regarding genotypic and phenotypic resistance testing see *Guidelines for the Use of Antiretroviral Agents in HIV-1-Infected Adults and Adolescents*.

Resistance testing should also be performed before initiation of ARV drugs in pregnant women with HIV RNA levels above the threshold for resistance testing (meaning >500–1,000 copies/mL) who received prophylaxis in previous pregnancies and are now restarting ARV drugs for prevention of perinatal

transmission. The identification of baseline resistance mutations may allow selection of more effective and durable ARV regimens.

Resistance testing also should be performed following initiation of an ARV regimen during pregnancy or in HIV-infected pregnant women who are receiving ART when they present for obstetrical care if there is suboptimal viral suppression or persistent viral load rebound to detectable levels after prior viral suppression on the ARV regimen.

In most settings, the results of resistance testing guide selection of the initial ARV regimen. In some situations in pregnant women, however, the clinician may choose to initiate an empiric ARV drug regimen before resistance-testing results are available to optimize prevention of perinatal transmission of HIV. Most experts believe that for women in the third trimester, the benefits of immediate initiation of ARV drugs for prevention of mother-to-child transmission (PMTCT), pending results of resistance testing, outweigh the possible risks of short-term use of a regimen that could be suboptimal because of pre-existing resistance. Once resistance-test results are obtained, the ARV drug regimen can be modified as needed.

## Incidence and Significance of Antiretroviral Drug Resistance in Pregnancy

The development of ARV drug resistance is one of the major factors leading to therapeutic failure in HIV-infected individuals. Additionally, pre-existing resistance to a drug in an ARV prophylaxis regimen may diminish the regimen's efficacy in preventing perinatal transmission. The development of resistance to drugs used during pregnancy for prophylaxis of perinatal transmission may limit future maternal treatment options or decrease the effectiveness of prophylactic regimens in the current pregnancy or during future pregnancies. Infant treatment options also may be limited if maternal resistance is present or develops and resistant virus is transmitted to the fetus.

Several factors unique to pregnancy may increase the risk of development of resistance. If drugs with significant differences in half-life (such as nevirapine or efavirenz combined with two nucleoside analogue drugs) are included in the ARV regimen, simultaneous postpartum discontinuation of all regimen components may result in persistent subtherapeutic drug levels and increase the risk of development of non-nucleoside reverse transcriptase inhibitor (NNRTI) resistance (see Stopping Antiretroviral Therapy during Pregnancy). Problems such as nausea and vomiting in early pregnancy may compromise adherence and increase the risk of resistance in women receiving ARV drugs. Pharmacokinetic changes during pregnancy, such as increased plasma volume and renal clearance, may lead to subtherapeutic drug levels, increasing the risk that resistance will develop.

ARV drug-resistance mutations have been observed in HIV-infected women receiving combination ARV drug regimens that are stopped postpartum and appear to be most common when drugs with different half-lives or with a low genetic barrier to resistance (such as NNRTI drugs or lamivudine and emtricitabine) are used during pregnancy and subsequently stopped.[1, 2] Thus, as noted above, resistance testing before initiation of ARV drugs is recommended in pregnant women with detectable HIV RNA levels who received prophylaxis in previous pregnancies and are restarting ARV drugs for prevention of perinatal transmission. Issues relating to discontinuation of NNRTI-based combination therapy are discussed in Prevention of Antiretroviral Drug Resistance.

## The Impact of Resistance on the Risk of Perinatal Transmission of HIV and Maternal Response to Subsequent Therapy

### *Perinatal Transmission*

Perinatal transmission of resistant virus has been reported, but appears to be unusual. There is little evidence that presence of resistance mutations increases risk of transmission when current recommendations for ARV

management in pregnancy are followed. A substudy of the Women and Infants Transmission Study followed pregnant women receiving zidovudine alone for treatment of HIV infection in the early 1990s. In this study, detection of zidovudine resistance conferred an increased risk of transmission when analysis was adjusted for duration of membrane rupture and total lymphocyte count;[3] however, women in this cohort had characteristics that would indicate a need for ART under the current Department of Health and Human Services recommendations for maternal health and for prevention of perinatal transmission. When transmitting mothers had mixed viral populations of wild-type and virus with low-level zidovudine resistance, only wild-type virus was detected in their infants,[4] and other studies have suggested that drug-resistance mutations may diminish viral fitness,[5] possibly leading to a decrease in transmissibility. In another study, prevalence of ARV drug resistance among HIV-infected newborns in New York State was examined. Eleven (12.1%) of 91 infants born between 1989 and 1999 and 8 (19%) of 42 infants born between 2001 and 2002 had mutations associated with decreased drug susceptibility. However, perinatal exposure to ARVs was not found to be a significant risk factor for the presence of resistance during either time period.[6, 7] Neither resistance to NNRTI drugs that develops as a result of exposure to single-dose nevirapine nor exposure to single-dose nevirapine in a prior pregnancy has been shown to affect perinatal transmission rates.[8, 9]

### *Maternal Response to Subsequent Treatment Regimens*

Few studies have evaluated response to subsequent therapy in women who receive current combination ARV regimens for prophylaxis and discontinue the drugs postpartum. In theory, however, resistance should not occur if the regimen that was discontinued had fully suppressed viral replication. The French Perinatal Cohort evaluated the association between exposure to ARV drugs for PMTCT during a previous pregnancy and presence of a detectable viral load with exposure to ARV drugs during the current pregnancy in women followed between 2005 and 2009.[10] In 1,166 women not receiving ARVs at the time of conception, 869 were ARV naive and 247 had received ARV drugs for PMTCT during a previous pregnancy. Previous ARV prophylaxis was protease inhibitor (PI) based in 48%, non-PI based in 4%, nucleoside reverse transcriptase inhibitor (NRTI) dual ARVs in 19%, and zidovudine as a single ARV in 29%. A PI-based ARV regimen was initiated in 90% of the women during the current pregnancy; in multivariate analysis, previous ARV exposure in a prior pregnancy was not associated with detectable viral load in the current pregnancy. A separate study reported in abstract form—ACTG A5227—evaluated viral suppression in 52 women with prior combination ARV exposure for PMTCT who had stopped ARV at least 24 weeks before study entry and were now initiating ART (efavirenz, tenofovir, and emtricitabine) for treatment.[11] None of the women had prior or recent resistance detected on standard bulk genotyping. Viral suppression was observed in 81% of women after 24 weeks of follow-up, with no difference in response by number of prior ARV exposures for PMTCT or the drug class of prior exposure.

## Management of Antiretroviral Drug Resistance during Pregnancy

For women who have documented zidovudine resistance and whose antepartum regimen does not include zidovudine, the drug still should be given intravenously during labor when indicated (meaning HIV RNA >400 copies/mL near delivery; see Intrapartum Antiretroviral Drug Treatment/Prophylaxis). Other ARVs should be continued orally during labor to the extent possible. The rationale for including zidovudine intrapartum when a woman is known to harbor virus with zidovudine resistance is based on several factors. Data thus far have suggested that only wild-type virus appears to be transmitted to infants by mothers who have mixed populations of wild-type virus and virus with low-level zidovudine resistance.[4] Other studies have suggested that drug-resistance mutations may diminish viral fitness and possibly decrease transmissibility.[5] The efficacy of the zidovudine prophylaxis appears to be based not only on a reduction in maternal HIV viral load but also on pre- and post-exposure prophylaxis in the infant.[12-14] Zidovudine crosses the placenta readily and has a high maternal-to-cord blood ratio. In addition, zidovudine is metabolized to the active triphosphate within the placenta,[15, 16] which may provide additional protection against transmission. Metabolism to the active triphosphate, which is required for activity of all nucleoside analogue agents, has

not been observed within the placenta with other nucleoside analogues that have been evaluated (didanosine and zalcitabine). Zidovudine penetrates the central nervous system (CNS) better than do other nucleoside analogues except stavudine, which has similar CNS penetration; this may help to eliminate a potential reservoir for transmitted HIV in the infant.[17, 18] Thus, intrapartum intravenous administration of zidovudine when indicated currently is recommended even in the presence of known resistance because of the drug's unique characteristics and its proven record in reducing perinatal transmission.

The optimal prophylactic regimen for newborns of women with ARV drug-resistant virus is unknown. Therefore, ARV prophylaxis for infants born to women with known or suspected drug-resistant virus should be determined with a pediatric HIV specialist, preferably before delivery (see Infant Antiretroviral Prophylaxis).

## Prevention of Antiretroviral Drug Resistance

The most effective way to prevent development of ARV drug resistance in pregnancy is to use and adhere to an effective combination of ARV drugs to achieve maximal viral suppression. More frequent monitoring of viral load in pregnant women than in non-pregnant individuals is recommended because of the potential increased risk of perinatal HIV infection associated with detectable HIV viremia during pregnancy (see Monitoring of the Woman and Fetus During Pregnancy).

Several studies have demonstrated that women's adherence to ART may worsen in the postpartum period.[19-22] Clinicians caring for postpartum women receiving ART should specifically address adherence, including evaluating specific factors that facilitate or impede adherence.

Because of the prolonged half-life of NNRTI drugs, if an NNRTI-based ARV regimen is stopped postpartum there is a risk of development of NNRTI-resistance mutations if all drugs in the regimen are stopped simultaneously. This has been demonstrated for nevirapine and efavirenz but may also be a problem with newer NNRTI drugs with long half-lives, such as etravirine and rilpivirine. Several studies have shown that development of NNRTI resistance is significantly decreased (but not eliminated) when zidovudine/lamivudine is given intrapartum and administered for 3 to 7 days postpartum in women who have received single-dose intrapartum nevirapine.[23-25] A variety of other regimens (such as tenofovir/emtricitabine, zidovudine/didanosine, zidovudine/didanosine/lopinavir/ritonavir) given for 7 to 30 days postpartum following maternal single-dose nevirapine have also been shown to be very effective in reducing the development of NNRTI resistance.[25-28] These data suggest that the NRTI components of an NNRTI-based regimen should be continued for 7 to 30 days after discontinuation of the NNRTI to minimize the risk of resistance. An alternative strategy is to substitute a PI for the NNRTI and to continue the PI with dual NRTIs for a period of time.[29] The optimal duration for continuation of either dual nucleosides or the substituted PI-based regimen after stopping the NNRTI is unknown. NNRTI drugs have long half-lives, and drug levels can persist for up to 1 to 3 weeks after stopping the drugs; efavirenz levels persist longer than nevirapine levels.[30, 31] More research is needed on the optimal duration of time and regimen to "cover" this period of prolonged NNRTI exposure to prevent the emergence of resistance after discontinuation of an NNRTI-based ARV regimen.

## References


1. Ellis GM, Huang S, Hitti J, Frenkel LM, P1022 Study Team. Selection of HIV resistance associated with antiretroviral therapy initiated due to pregnancy and suspended postpartum. *J Acquir Immune Defic Syndr*. Nov 1 2011;58(3):241-247. Available at http://www.ncbi.nlm.nih.gov/pubmed/21765365.

2. Paredes R, Cheng I, Kuritzkes DR, Tuomala RE, Women and Infants Transmission Study (WITS) Group. Postpartum antiretroviral drug resistance in HIV-1-infected women receiving pregnancy-limited antiretroviral therapy. *AIDS*. Jan 2

2010;24(1):45-53. Available at http://www.ncbi.nlm.nih.gov/pubmed/19915448.

3. Welles SL, Pitt J, Colgrove R, et al. HIV-1 genotypic zidovudine drug resistance and the risk of maternal—infant transmission in the women and infants transmission study. The Women and Infants Transmission Study Group. *AIDS*. Feb 18 2000;14(3):263-271. Available at http://www.ncbi.nlm.nih.gov/pubmed/10716502.
4. Colgrove RC, Pitt J, Chung PH, Welles SL, Japour AJ. Selective vertical transmission of HIV-1 antiretroviral resistance mutations. *AIDS*. Dec 3 1998;12(17):2281-2288. Available at http://www.ncbi.nlm.nih.gov/pubmed/9863870.
5. Sheth PM, Kovacs C, Kemal KS, et al. Persistent HIV RNA shedding in semen despite effective antiretroviral therapy. *AIDS*. Sep 24 2009;23(15):2050-2054. Available at http://www.ncbi.nlm.nih.gov/pubmed/19710596.
6. Taylor S, Davies S. Antiretroviral drug concentrations in the male and female genital tract: implications for the sexual transmission of HIV. *Curr Opin HIV AIDS*. Jul 2010;5(4):335-343. Available at http://www.ncbi.nlm.nih.gov/pubmed/20543610.
7. Donnell D, Baeten JM, Kiarie J, et al. Heterosexual HIV-1 transmission after initiation of antiretroviral therapy: a prospective cohort analysis. *Lancet*. Jun 12 2010;375(9731):2092-2098. Available at http://www.ncbi.nlm.nih.gov/pubmed/20537376.
8. Del Romero J, Castilla J, Hernando V, Rodriguez C, Garcia S. Combined antiretroviral treatment and heterosexual transmission of HIV-1: cross sectional and prospective cohort study. *BMJ*. 2010;340:c2205. Available at http://www.ncbi.nlm.nih.gov/pubmed/20472675.
9. Martinson NA, Ekouevi DK, Dabis F, et al. Transmission rates in consecutive pregnancies exposed to single-dose nevirapine in Soweto, South Africa and Abidjan, Cote d'Ivoire. *J Acquir Immune Defic Syndr*. Jun 1 2007;45(2):206-209. Available at http://www.ncbi.nlm.nih.gov/pubmed/17438480.
10. Briand N, Mandelbrot L, Blanche S, et al. Previous antiretroviral therapy for prevention of mother-to-child transmission of HIV does not hamper the initial response to PI-based multitherapy during subsequent pregnancy. *J Acquir Immune Defic Syndr*. Jun 1 2011;57(2):126-135. Available at http://www.ncbi.nlm.nih.gov/pubmed/21436712.
11. Vogler MA, Smeaton L, et al. Effect of prior cART used only to prevent MTCT of HIV-1 on subsequent cART efficacy in HIV+ women restarting HIV therapy with a standard first-line regimen: ACTG A5227 Study. Paper presented at: 18th Conference on Retroviruses and Opportunistic Infections (CROI); February 27-March 2, 2011; Boston, MA. Abstract 752.
12. Sperling RS, Shapiro DE, Coombs RW, et al. Maternal viral load, zidovudine treatment, and the risk of transmission of human immunodeficiency virus type 1 from mother to infant. Pediatric AIDS Clinical Trials Group Protocol 076 Study Group. *N Engl J Med*. Nov 28 1996;335(22):1621-1629. Available at http://www.ncbi.nlm.nih.gov/pubmed/8965861.
13. Wade NA, Birkhead GS, Warren BL, et al. Abbreviated regimens of zidovudine prophylaxis and perinatal transmission of the human immunodeficiency virus. *N Engl J Med*. Nov 12 1998;339(20):1409-1414. Available at http://www.ncbi.nlm.nih.gov/pubmed/9811915.
14. Melvin AJ, Burchett SK, Watts DH, et al. Effect of pregnancy and zidovudine therapy on viral load in HIV-1-infected women. *J Acquir Immune Defic Syndr Hum Retrovirol*. Mar 1 1997;14(3):232-236. Available at http://www.ncbi.nlm.nih.gov/pubmed/9117455.
15. Qian M, Bui T, Ho RJ, Unadkat JD. Metabolism of 3'-azido-3'-deoxythymidine (AZT) in human placental trophoblasts and Hofbauer cells. *Biochemical pharmacology*. Jul 19 1994;48(2):383-389. Available at http://www.ncbi.nlm.nih.gov/pubmed/8053935.
16. Sandberg JA, Binienda Z, Lipe G, et al. Placental transfer and fetal disposition of 2',3'-dideoxycytidine and 2',3'-dideoxyinosine in the rhesus monkey. *Drug metabolism and disposition: the biological fate of chemicals*. Aug 1995;23(8):881-884. Available at http://www.ncbi.nlm.nih.gov/pubmed/7493557.
17. Peters PJ, Stringer J, McConnell MS, et al. Nevirapine-associated hepatotoxicity was not predicted by CD4 count ≥250 cells/muL among women in Zambia, Thailand and Kenya. *HIV Med*. Nov 2010;11(10):650-660. Available at http://www.ncbi.nlm.nih.gov/pubmed/20659176.

18. Thomas SA. Anti-HIV drug distribution to the central nervous system. *Curr Pharm Des*. 2004;10(12):1313-1324. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&dopt=Citation&list_uids=15134483.

19. Bardeguez AD, Lindsey JC, Shannon M, et al. Adherence to antiretrovirals among US women during and after pregnancy. *J Acquir Immune Defic Syndr*. Aug 1 2008;48(4):408-417. Available at http://www.ncbi.nlm.nih.gov/pubmed/18614923.

20. Mellins CA, Chu C, Malee K, et al. Adherence to antiretroviral treatment among pregnant and postpartum HIV-infected women. *AIDS Care*. Sep 2008;20(8):958-968. Available at http://www.ncbi.nlm.nih.gov/pubmed/18608073.

21. Rana AI, Gillani FS, Flanigan TP, Nash BT, Beckwith CG. Follow-up care among HIV-infected pregnant women in Mississippi. *J Womens Health (Larchmt)*. Oct 2010;19(10):1863-1867. Available at http://www.ncbi.nlm.nih.gov/pubmed/20831428.

22. Anderson J. Women and HIV: motherhood and more. *Curr Opin Infect Dis*. Feb 2012;25(1):58-65. Available at http://www.ncbi.nlm.nih.gov/pubmed/22156896.

23. McIntyre JA, Hopley M, Moodley D, et al. Efficacy of short-course AZT plus 3TC to reduce nevirapine resistance in the prevention of mother-to-child HIV transmission: a randomized clinical trial. *PLoS Med*. Oct 2009;6(10):e1000172. Available at http://www.ncbi.nlm.nih.gov/pubmed/19859531.

24. Chaix ML, Ekouevi DK, Rouet F, et al. Low risk of nevirapine resistance mutations in the prevention of mother-to-child transmission of HIV-1: Agence Nationale de Recherches sur le SIDA Ditrame Plus, Abidjan, Cote d'Ivoire. *J Infect Dis*. Feb 15 2006;193(4):482-487. Available at http://www.ncbi.nlm.nih.gov/pubmed/16425126.

25. Farr SL, Nelson JA, Ng'ombe TJ, et al. Addition of 7 days of zidovudine plus lamivudine to peripartum single-dose nevirapine effectively reduces nevirapine resistance postpartum in HIV-infected mothers in Malawi. *J Acquir Immune Defic Syndr*. Aug 2010;54(5):515-523. Available at http://www.ncbi.nlm.nih.gov/pubmed/20672451.

26. TEmAA ANRS 12109 Study Group, Arrive E, Chaix ML, et al. Maternal and nenonatal tenofovir and emtricitabine to prevent vertical transmission of HIV-1: tolerance and resistance. *AIDS*. Oct 23 2010;24(16):2481-2488. Available at http://www.ncbi.nlm.nih.gov/pubmed/20827166.

27. Lallemant M, Ngo-Giang-Huong N, Jourdain G, et al. Efficacy and safety of 1-month postpartum zidovudine-didanosine to prevent HIV-resistance mutations after intrapartum single-dose nevirapine. *Clin Infect Dis*. Mar 15 2010;50(6):898-908. Available at http://www.ncbi.nlm.nih.gov/pubmed/20158398.

28. Van Dyke RB, Ngo-Giang-Huong N, Shapiro DE, et al. A comparison of 3 regimens to prevent nevirapine resistance mutations in HIV-infected pregnant women receiving a singly intrapartum dose of nevirapine. *Clin Infect Dis*. Jan 15 2012;54(2):285-93. Available at http://www.ncbi.nlm.nih.gov/pubmed/22144539.

29. Fox Z, Phillips A, Cohen C, et al. Viral resuppression and detection of drug resistance following interruption of a suppressive non-nucleoside reverse transcriptase inhibitor-based regimen. *AIDS*. Nov 12 2008;22(17):2279-2289. Available at http://www.ncbi.nlm.nih.gov/pubmed/18981767.

30. Cressey TR, Jourdain G, Lallemant MJ, et al. Persistence of nevirapine exposure during the postpartum period after intrapartum single-dose nevirapine in addition to zidovudine prophylaxis for the prevention of mother-to-child transmission of HIV-1. *J Acquir Immune Defic Syndr*. Mar 1 2005;38(3):283-288. Available at http://www.ncbi.nlm.nih.gov/pubmed/15735445.

31. Sadiq ST, Fredericks S, Khoo SH, Rice P, Holt DW. Efavirenz detectable in plasma 8 weeks after stopping therapy and subsequent development of non-nucleoside reverse transcriptase inhibitor-associated resistance. *AIDS*. Oct 14 2005;19(15):1716-1717. Available at http://www.ncbi.nlm.nih.gov/pubmed/16184054.

# Intrapartum Care

## Intrapartum Antiretroviral Therapy/Prophylaxis (Last updated July 31, 2012; last reviewed July 31, 2012

| Panel's Recommendations |
|---|
| • Women who are receiving an antepartum combination antiretroviral (ARV) drug regimen should continue this regimen on schedule as much as possible during labor and before scheduled cesarean delivery **(AIII)**. |
| • Intravenous (IV) zidovudine should be administered to HIV-infected women with HIV RNA ≥400 copies/mL (or unknown HIV RNA) near delivery, regardless of antepartum regimen or mode of delivery **(AI)**. |
| • IV zidovudine is not required for HIV-infected women receiving combination ARV regimens who have HIV RNA <400 copies/mL near delivery **(BII)**. |
| • For women who have received antepartum ARV drugs but have suboptimal viral suppression near delivery (that is, HIV RNA >1,000 copies/mL), scheduled cesarean delivery is recommended (see Mode of Delivery) **(AI)**. |
| • Women whose HIV status is unknown who present in labor should undergo rapid HIV antibody testing **(AII)**. If the results are positive, a confirmatory HIV test should be done as soon as possible and maternal (IV zidovudine)/infant (combination ARV prophylaxis) ARV drugs should be initiated pending results of the confirmatory test **(AII)**. If the confirmatory HIV test is positive, infant ARV drugs should be continued for 6 weeks (see Infant Antiretroviral Prophylaxis) **(AI)**; if the test is negative, the infant ARV drugs should be stopped. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

### *Women Who Have Received Antepartum Antiretroviral Drugs*

#### Use of Intravenous Zidovudine during Labor

The PACTG 076 zidovudine regimen included a continuous intravenous (IV) infusion of zidovudine during labor (initial loading dose of 2 mg/kg IV over 1 hour, followed by continuous infusion of 1 mg/kg/hour until delivery) for all women. This regimen along with maternal antepartum and infant zidovudine reduced perinatal transmission by 66% overall. Combination antiretroviral (ARV) regimens are now recommended for treatment and prevention of perinatal transmission of HIV; the additional benefit of IV zidovudine in women receiving combination regimens has not been evaluated in randomized clinical trials. The French Perinatal Cohort evaluated transmission in >5,000 HIV-infected pregnant women receiving ARV (19% zidovudine alone, 33% dual ARV, and 48% triple ARV) who delivered between 1997 and 2004, stratified by viral load at delivery; 96% received IV intrapartum zidovudine.[1] Overall, intrapartum IV zidovudine prophylaxis was associated with lower risk of transmission (1.2% [59/5,006] transmission with intrapartum prophylaxis vs. 3.1% [7/230] without intrapartum prophylaxis, $P$ =.025) but this association was related to HIV RNA level at delivery. In 364 women who had HIV RNA >10,000 copies/mL at delivery, intrapartum prophylaxis was strongly associated with a lower risk of transmission: 5.3% (18/339) with intrapartum prophylaxis versus 22.7% (5/22) without intrapartum prophylaxis ($P$ =.009). However, intrapartum prophylaxis was not associated with transmission in 2,845 women with HIV RNA <400 copies/mL at delivery: 0.6% (17/2,750) with intrapartum prophylaxis versus 0% (0/95) without intrapartum prophylaxis. Data were not provided for women with viral load 400 to 9,999 copies/mL. Based on this study, IV

zidovudine is not required for HIV-infected women receiving combination ARV regimens with HIV RNA <400 copies/mL near delivery but should continue to be administered to HIV-infected women with HIV RNA ≥400 copies/mL near delivery (or unknown HIV RNA levels), regardless of antepartum regimen.

In women with HIV RNA >400 copies/mL receiving a scheduled cesarean delivery for prevention of transmission, IV zidovudine administration should begin 3 hours before the scheduled operative delivery. This recommendation is based on a pharmacokinetic (PK) study of zidovudine given orally during pregnancy and as a continuous infusion during labor. Maternal zidovudine levels were measured at baseline, after the initial IV loading dose and then every 3 to 4 hours until delivery, and in cord blood.[2] Systemic and intracellular zidovudine levels increased from baseline but appeared to stabilize after 3 hours of infusion; cord blood zidovudine levels were assocated with maternal levels and maternal infusion duration. If cesarean section is being performed for other indications and maternal viral load is <400 copies/mL near the time of delivery, administration of IV zidovudine is not required.

If antenatal use of zidovudine was precluded by known or suspected zidovudine resistance, intrapartum use of the drug still should be recommended in women with HIV RNA >400 copies/mL near delivery, except in women with documented histories of hypersensitivity. This intrapartum use of the drug is recommended because of the unique characteristics of zidovudine and its proven record in reducing perinatal transmission, even in the presence of maternal resistance to the drug (see Management of Antiretroviral Drug Resistance during Pregnancy).

In some international studies, oral, rather than IV zidovudine has been administered during labor (see Lessons from Clinical Trials of Antiretroviral Interventions to Reduce Perinatal Transmission of HIV). Data are limited on the PKs of oral compared with IV zidovudine during labor. Additionally, the drug levels needed for prophylaxis are unknown, although extrapolations have been made using therapeutic drug level targets. In a study of oral intrapartum zidovudine 300 mg every 3 hours in Thailand, most cord blood zidovudine levels were at therapeutic levels but were lower than those reported after continuous IV administration; 17% of infants had subtherapeutic levels at birth.[3] In another study, the PKs of two dosing regimens of oral zidovudine during labor were evaluated in 10 HIV-infected pregnant women.[4] The oral regimen was well tolerated; plasma zidovudine concentrations were substantially lower with 300 mg every 3 hours given orally during labor than previously reported with continuous IV therapy. A revised regimen with a 600-mg oral loading dose, followed by 400 mg every 3 hours, resulted in increased zidovudine concentrations but inter-patient variance was significant. In both cohorts, PK parameters suggested erratic absorption during labor. Therefore, in women with HIV RNA >400 copies/mL near delivery for whom zidovudine is recommended, IV would be preferred to oral administration in the United States; in situations where IV administration is not possible, oral administration can be considered.

### Continuation of Antenatal Antiretroviral Drugs during Labor

Women who are receiving an antepartum combination ARV drug regimen should continue that regimen on schedule as much as possible during the intrapartum period to provide maximal virologic effect and to minimize the chance of development of drug resistance. If oral zidovudine is part of the antepartum regimen and a woman's HIV-1 RNA viral load is >400 copies/mL, the oral zidovudine component of her regimen should be stopped while she receives IV zidovudine. When cesarean delivery is planned, oral medications can be continued preoperatively with sips of water. Medications requiring food ingestion for absorption can be taken with liquid dietary supplements, contingent on consultation with the attending anesthesiologist in the preoperative period. If the maternal ARV regimen must be interrupted temporarily (meaning for less than 24 hours) during the peripartum period, all drugs should be stopped and reinstituted simultaneously to minimize the chance that resistance will develop.

### *Women Who Have Received Antepartum Antiretroviral Drugs But Have Suboptimal Viral Suppression Near Delivery*

Women who have received combination ARV drug regimens may not achieve complete viral suppression by the time of delivery because of factors such as poor adherence, viral resistance, or late entry into care. Regardless of the reason, all women who have HIV RNA levels >1,000 copies/mL near the time of delivery should be offered a scheduled cesarean delivery at 38 weeks, which may significantly reduce risk of transmission (see Transmission and Mode of Delivery).

Women with incomplete viral suppression at the time of delivery should receive IV zidovudine along with their other ARVs orally, as described above. In certain high-risk situations, additional medications for prophylaxis in infants may be warranted, such as in cases where maternal HIV RNA levels are high at or near the time of delivery, especially if delivery is not a scheduled cesarean delivery (see Infant Antiretroviral Prophylaxis and Table 9).

### *Women Who Have Not Received Antepartum Antiretroviral Drugs*

#### Women Who Present in Labor Without Documentation of HIV Status

All women without documentation of HIV status at the time of labor should be screened with rapid HIV testing unless they decline (opt-out screening). Rapid HIV testing is also recommended for women presenting in labor who tested negative for HIV in early pregnancy but are at increased risk of HIV infection and were not retested in the third trimester.[5] Factors that may increase risk of infection include diagnosis of a sexually transmitted disease, illicit drug use or exchange of sex for money or drugs, multiple sexual partners during pregnancy, a sexual partner at risk of HIV infection, signs/symptoms of acute HIV infection, or living in a region with an elevated incidence of HIV in women of childbearing age and not undergoing repeat HIV testing in the third trimester.[5]

Rapid HIV antibody testing should be available on a 24-hour basis at all facilities with a maternity service and/or neonatal intensive care unit. Statutes and regulations regarding rapid testing vary from state to state; see http://www.nccc.ucsf.edu/consultation_library/state_hiv_testing_laws for a review of state HIV testing laws. Current information on rapid testing also should be available at all facilities with a maternity service and/or neonatal intensive care unit.

Women with positive rapid HIV antibody tests should be presumed to be infected until standard HIV antibody confirmatory testing clarifies their infection status. IV zidovudine should be started immediately in all women with positive rapid HIV tests in labor to prevent perinatal transmission of HIV, as discussed below.

In the postpartum period, along with confirmatory HIV antibody testing, these women should receive appropriate assessments as soon as possible to determine their health status, including CD4 T-lymphocyte count and HIV-1 RNA viral load. Arrangements also should be made for establishing HIV care and providing ongoing psychosocial support after discharge.

#### Choice of Intrapartum/Postpartum Antiretroviral Regimen for Women without Antepartum Antiretroviral Therapy

All HIV-infected women who have not received antepartum ARV drugs should have IV zidovudine started immediately to prevent perinatal transmission of HIV. Although intrapartum/neonatal ARV medications will not prevent perinatal transmission that occurs before labor, most transmission occurs near to or during labor and delivery. Pre-exposure prophylaxis for the fetus can be provided by giving mothers a drug that rapidly crosses the placenta, producing fetal systemic ARV drug levels during intensive exposure to HIV in maternal genital secretions and in blood during birth. In general, zidovudine and other nucleoside reverse transcriptase inhibitor drugs and non-nucleoside reverse transcriptase inhibitor drugs cross the placenta well, whereas

protease inhibitors do not (see Table 5).

A large international trial (NICHD-HPTN 040/PACTG 1043) demonstrated that adding ARV agents to the neonatal portion of the intrapartum/neonatal zidovudine regimen can further reduce mother-to-child transmission of HIV for mothers who have received no antepartum ARV drugs (see Infant Antiretroviral Prophylaxis). In this study, women who had not received antepartum ARV drugs received IV zidovudine if they were identified in labor or no zidovudine when diagnosed immediately postpartum, and their infants received either 6 weeks of zidovudine alone or zidovudine in combination with other agents; the combination infant regimens resulted in a 50% reduction in transmission compared with zidovudine alone. Therefore, no additional intrapartum drugs, including intrapartum maternal single-dose nevirapine, are indicated for a woman in this situation.[6]

## References:


1. Warszawski J, Tubiana R, Le Chenadec J, et al. Mother-to-child HIV transmission despite antiretroviral therapy in the ANRS French Perinatal Cohort. *AIDS*. Jan 11 2008;22(2):289-299. Available at http://www.ncbi.nlm.nih.gov/pubmed/18097232.
2. Rodman JH, Flynn PM, Robbins B, et al. Systemic pharmacokinetics and cellular pharmacology of zidovudine in human immunodeficiency virus type 1-infected women and newborn infants. *J Infect Dis*. Dec 1999;180(6):1844-1850. Available at http://www.ncbi.nlm.nih.gov/pubmed/10558940.
3. Bhadrakom C, Simonds RJ, Mei JV, et al. Oral zidovudine during labor to prevent perinatal HIV transmission, Bangkok: tolerance and zidovudine concentration in cord blood. Bangkok Collaborative Perinatal HIV Transmission Study Group. *AIDS*. Mar 31 2000;14(5):509-516. Available at http://www.ncbi.nlm.nih.gov/pubmed/10780713.
4. Mirochnick M, Rodman JH, Robbins BL, et al. Pharmacokinetics of oral zidovudine administered during labour: a preliminary study. *HIV Med*. Oct 2007;8(7):451-456. Available at http://www.ncbi.nlm.nih.gov/pubmed/17760737.
5. Branson BM, Handsfield HH, Lampe MA, et al. Revised recommendations for HIV testing of adults, adolescents, and pregnant women in health-care settings. *MMWR Recomm Rep*. Sep 22 2006;55(RR-14):1-17; quiz CE11-14. Available at http://www.ncbi.nlm.nih.gov/pubmed/16988643.
6. Nielsen-Saines K, Watts DH, Veloso VG, et al. Three postpartum antiretroviral regimens to prevent intrapartum HIV infection. *N Engl J Med*. Jun 21 2012;366(25):2368-2379. Available at http://www.ncbi.nlm.nih.gov/pubmed/22716975.

## Transmission and Mode of Delivery (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendations |
|---|
| • Scheduled cesarean delivery at 38 weeks' gestation to minimize perinatal transmission of HIV is recommended for women with HIV RNA levels >1,000 copies/mL or unknown HIV levels near the time of delivery, irrespective of administration of antepartum antiretroviral (ARV) drugs **(AII)**. Scheduled cesarean delivery is not recommended for prevention of perinatal transmission in pregnant women receiving combination ARV drugs with plasma HIV RNA levels <1,000 copies/mL near the time of delivery **(BIII)**. Data are insufficient to evaluate the potential benefit of cesarean delivery used solely for prevention of perinatal transmission in women with HIV RNA levels <1,000 copies/mL, and given the low rate of transmission in these patients, it is unclear whether scheduled cesarean delivery would confer additional benefit in reducing transmission. In women with HIV RNA levels <1,000 copies/mL, cesarean delivery performed for standard obstetrical indications should be scheduled for 39 weeks' gestation. |
| • It is not clear whether cesarean delivery after rupture of membranes or onset of labor provides benefit in preventing perinatal transmission. Management of women originally scheduled for cesarean delivery who present with ruptured membranes or in labor must be individualized at the time of presentation based on duration of rupture and/or labor, plasma HIV RNA level, and current ARV regimen **(BII)**. |
| • Women should be informed of the risks associated with cesarean delivery. If the indication for cesarean delivery is prevention of perinatal transmission of HIV, the risks to a woman should be balanced with potential benefits expected for the neonate **(AII)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

### *Basis for Current Recommendations*

Scheduled cesarean delivery, defined as cesarean delivery performed before the onset of labor and before rupture of membranes, is recommended for prevention of perinatal transmission of HIV in women with HIV RNA levels >1,000 copies/mL near the time of delivery and for women with unknown HIV RNA levels.[1]

This recommendation is based on findings from a multicenter, randomized clinical trial[2] and from a large individual patient data meta-analysis.[3] These two studies were conducted at a time when the majority of HIV-infected women received no antiretroviral (ARV) medications or zidovudine as a single drug and before the availability of viral load information. Study results have since been extrapolated to make current recommendations about the mode of delivery in an era when combination ARV regimens during pregnancy are recommended and viral load information is readily available.

In the randomized clinical trial, 1.8% of infants born to women randomized to undergo cesarean delivery were HIV infected compared with 10.5% of infants born to women randomized to vaginal delivery ($P < .001$). When adjusted for ARV use in pregnancy (zidovudine alone), scheduled cesarean delivery lowered risk of HIV transmission by 80%, although the results were no longer statistically significant (odds ratio [OR] 0.2; 95% confidence interval [CI], 0–1.7). The protective effect still remained for scheduled delivery (adjusted OR [AOR] 0.3; 95% CI, 0.1–0.8) but not for emergency cesarean delivery (AOR 1.0; 95% CI, 0.3–3.7) when the data were analyzed by actual mode of delivery rather than by the group to which women were allocated.[2] Results from a large meta-analysis of individual patient data from 15 prospective cohort studies also demonstrated the benefit of scheduled cesarean delivery with a 50% reduction in risk.[3] Primarily based on these data, the American College of Obstetricians and Gynecologists (ACOG) has recommended consideration of scheduled cesarean delivery for HIV-infected pregnant women since 1999.[4]

## HIV RNA Level of 1,000 copies/mL as a Threshold for Recommendation of Scheduled Cesarean Delivery

The original ACOG committee opinion was updated in 2000 to include further refinements based on HIV RNA levels.[1] Currently, ACOG[1] recommends that women with HIV RNA >1,000 copies/mL be counseled regarding the potential benefits of scheduled cesarean delivery. Initially, the threshold of 1,000 copies/mL was based largely on data from the Women and Infants Transmission Study, a large prospective cohort study that reported no HIV transmission among 57 women with HIV RNA levels less than 1,000 copies/mL.[5] Studies reported since then have demonstrated that HIV transmission can occur in infants born to women with low viral loads.

In an analysis of 957 women with plasma viral loads <1,000 copies/mL, cesarean delivery (scheduled or urgent) reduced risk of HIV transmission when adjusting for potential confounders including receipt of maternal ARV medications; however, zidovudine alone was the regimen primarily used as prophylaxis (AOR 0.30; $P = 0.022$).[6] Among infants born to 834 women with HIV RNA <1,000 copies/mL receiving ARV medications, 8 (1%) were HIV infected. In a more recent report from a comprehensive national surveillance system in the United Kingdom and Ireland, 3 (0.1%) of 2,309 and 12 (1.2%) of 1,023 infants born to women with HIV RNA levels <50 copies/mL and 50 to 999 copies/mL, respectively, were HIV infected.[7]

The recent studies demonstrate that transmission can occur even at very low HIV RNA levels. However, given the low rate of transmission in this group, it is unclear whether scheduled cesarean delivery confers any additional benefit in reducing transmission. Although decisions about mode of delivery for women with HIV RNA levels <1,000 copies/mL should be individualized based on discussion between the obstetrician and the mother, women should be informed that there is no evidence of benefit for scheduled cesarean delivery performed solely for prevention of perinatal transmission in women with HIV RNA <1,000 copies/mL and that it is not routinely recommended in this group.

## Scheduled Cesarean Delivery in the Highly Active Antiretroviral Therapy Era

In surveillance data from the United Kingdom and Ireland, pregnant women receiving combination ARV regimens (meaning at least 3 drugs) had transmission rates of about 1%, unadjusted for mode of delivery.[7] Given the low transmission rates achievable with use of maternal combination ARV drug regimens, the benefit of scheduled cesarean delivery is difficult to evaluate. Both the randomized clinical trial[2] and meta-analysis[3] documenting the benefits of cesarean delivery included mostly women who were receiving either no ARVs or zidovudine alone. However, other data partially address this issue.

In a report from the European Collaborative Study that included data from 4,525 women, the overall transmission rate in the subset of women on a combination ARV regimen was 1.2% (11 of 918).[8] In the subset of 560 women with undetectable HIV RNA levels (≤50 to ≤200 copies/mL, depending on site), scheduled cesarean delivery was associated with a significant reduction in perinatal transmission in univariate analysis (OR 0.07; 95% CI, 0.02–0.31; $P = .0004$). However, after adjustment for ARV drug use (none vs. any), the effect was no longer significant (AOR 0.52; 95% CI, 0.14–2.03; $P = .359$). Similarly, data from a European surveillance study did not demonstrate a statistically significant difference in transmission rates between scheduled cesarean delivery and planned vaginal delivery (AOR 1.24; 95% CI, 0.34–4.5) in women on combination ARV regimens.[7] The transmission rate in all women who received at least 14 days of ARV medications was 0.8% (40 of 4,864), regardless of mode of delivery. Therefore, no evidence to date suggests any benefit from scheduled cesarean delivery in women who have been receiving combination ARV medications for several weeks and who have achieved virologic supression.

When the delivery method selected is scheduled cesarean delivery and the maternal viral load is ≥400 copies/mL, administer a 1-hour loading dose and continuous intravenous (IV) zidovudine for 2 hours (3 hours total) before scheduled cesarean delivery. In a study of the pharmacokinetics of IV zidovudine in 28

pregnant women, the ratio of cord blood to maternal zidovudine levels increased significantly in women who received IV zidovudine for 3 to 6 hours compared with <3 hours before delivery (1.0 vs. 0.55, respectively).[9] This suggests that an interval of at least 3 hours may provide adequate time to reach equilibrium across the placenta, although the relationship between specific cord blood zidovudine levels or cord blood-to-maternal-zidovudine levels and efficacy in preventing mother-to-child transmission of HIV is unknown.

Because unscheduled cesarean delivery is performed for both maternal and fetal indications, when an unscheduled cesarean delivery is indicated in a woman who has a viral load ≥400 copies/ml, consideration can be given to shortening the interval between initiation of IV zidovudine administration and delivery. For example, some experts recommend administering the 1-hour loading dose of IV zidovudine and not waiting to complete additional administration before proceeding with delivery.

### Women Presenting Late in Pregnancy

HIV-infected women who present late in pregnancy and are not receiving ARV drugs may not have HIV RNA results available before delivery. Without current therapy, HIV RNA levels are unlikely to be <1,000 copies/mL at baseline. Even if combination ARV medications were begun immediately, reduction in plasma HIV RNA to undetectable levels usually takes several weeks, depending on the kinetics of viral decay for a particular drug regimen.[10] In this instance, scheduled cesarean delivery is likely to provide additional benefit in reducing the risk of perinatal transmission of HIV for women, unless viral suppression can be documented before 38 weeks' gestation.

### Timing of Scheduled Cesarean Delivery

In general, ACOG recommends that scheduled cesarean delivery not be performed before 39 weeks' gestation because of the risk of iatrogenic prematurity.[11, 12] However, in cases of cesarean delivery performed to prevent transmission of HIV, ACOG recommends scheduling cesarean delivery at 38 weeks' gestation in order to decrease the likelihood of onset of labor or rupture of membranes before delivery.[1] In all women undergoing repeat cesarean delivery, the risk of any neonatal adverse event—including neonatal death, respiratory complications, hypoglycemia, newborn sepsis, or admission to the neonatal intensive care unit—is 15.3% at 37 weeks, 11.0% at 38 weeks, and 8.0% at 39 weeks.[12] Gestational age should be determined by best obstetrical dating criteria, including last menstrual period and early ultrasound for dating purposes. Amniocentesis to document lung maturity should be avoided when possible in HIV-infected women and is rarely indicated before scheduled cesarean section for prevention of HIV transmission.

Among 1,194 infants born to HIV-infected mothers, 9 (1.6%) infants born vaginally had respiratory distress syndrome (RDS) compared with 18 (4.4%) infants born by scheduled cesearean delivery ($P$ <0.001). There was no statistically significant association between mode of delivery and infant RDS in an adjusted model that included infant gestational age and birth weight.[13] Although newborn complications may be increased in planned births <39 weeks' gestation, the benefits of planned cesarean delivery at 38 weeks are generally thought to outweigh the risks if the procedure is performed for prevention of HIV transmission. When cesarean delivery is performed in HIV-infected women for an indication other than decreasing HIV transmission, cesarean delivery should be scheduled at 39 weeks, based on ACOG guidelines.

### Risk of Maternal Complications

Administration of perioperative antimicrobial prophylaxis is recommended for all women to decrease maternal infectious morbidity associated with cesarean delivery. Most studies have demonstrated that HIV-infected women have increased rates of postoperative complications, mostly infectious, compared with HIV-uninfected women and that risk of complications is related to degree of immunosuppression.[14-19] Furthermore, a Cochrane review of six studies of HIV-infected women concluded that urgent cesarean delivery was associated with the highest risk of postpartum morbidity, scheduled cesarean delivery was

intermediate in risk, and vaginal delivery had the lowest risk of morbidity.[20] Complication rates in most studies [2, 21-25] were within the range reported in populations of HIV-uninfected women with similar risk factors and not of sufficient frequency or severity to outweigh the potential benefit of reduced perinatal HIV transmission. Therefore, HIV-infected women should be counseled regarding the risks associated with undergoing cesarean delivery and the potential benefits in decreasing perinatal transmission of HIV if HIV RNA levels at term are >1,000 copies/mL.

### Management of Women Who Present in Early Labor or With Ruptured Membranes

Few data are available to address the question of whether performing cesarean delivery after the onset of labor or membrane rupture decreases risk of perinatal transmission of HIV. Most studies have shown a similar risk of transmission for cesarean delivery performed for obstetric indications after labor and membrane rupture and for vaginal delivery. In one study, the HIV transmission rate was similar in women undergoing emergency cesarean delivery and those delivering vaginally (1.6% vs. 1.9%, respectively).[7] A meta-analysis of HIV-infected women, most of whom were on zidovudine as a single drug or receiving no ARV medications, demonstrated a 2% increased transmission risk for every additional hour of ruptured membranes.[26] However, it is not clear how soon after the onset of labor or the rupture of membranes the benefit of cesarean delivery is lost.[27] Therefore, the decision about whether to deliver by expeditious cesarean section for prevention of perinatal transmission in women originally scheduled for cesarean delivery who then present with ruptured membranes or in labor must be individualized, taking into account duration of rupture or labor upon presentation, plasma RNA level, and current ARV drug regimen status. The ARV drug regimen should be continued and IV zidovudine initiated, if previously planned.

When membrane rupture occurs before 37 weeks' gestation, decisions about timing of delivery should be based on best obstetrical practices, taking into account risks to the infant of prematurity and of HIV transmission. Steroids should be given, if appropriate, to accelerate fetal lung maturity because no data exist to suggest that these recommendations need to be altered for HIV-infected women. When the decision is made to deliver, route of delivery should be according to obstetrical indications.

Table 8 summarizes recommendations regarding mode of delivery for different clinical scenarios.

**Table 8. Clinical Scenarios and Recommendations Regarding Mode of Delivery to Reduce Perinatal Transmission of HIV (page 1 of 2)**

| Clinical Scenario | Recommendations |
|---|---|
| HIV-infected women presenting late in pregnancy (after about 36 weeks' gestation), known to be HIV infected but not receiving ARV medications, and who have HIV RNA level and CD4 T-lymphocyte (CD4-cell) counts pending but unlikely to be available before delivery. | • Start antiretroviral (ARV) medications as per Table 6.<br>• Provide counseling on the likelihood that scheduled cesarean delivery will reduce the risk of mother-to-child transmission, if viral suppression cannot be documented before 38 weeks. Include information on increased maternal risks of cesarean delivery, including risks related to anesthesia and surgery and increased rates of postoperative infection.<br>• When the delivery method selected is scheduled cesarean, perform the procedure at 38 weeks' gestation, as determined by best obstetrical dating.<br>• Administer a 1-hour intraveneous (IV) loading dose followed by continuous IV zidovudine for 2 hours (3 hours total) before scheduled cesarean.<br>• Continue other ARV medications on schedule, as much as possible, before and after surgery.<br>• All standard cesarean delivery management should be recommended, including use of prophylactic antibiotics. |

**Table 8. Clinical Scenarios and Recommendations Regarding Mode of Delivery to Reduce Perinatal Transmission of HIV (page 2 of 2)**

| Clinical Scenario | Recommendations |
|---|---|
| HIV-infected women who began prenatal care early in the third trimester, are receiving combination ARV drug regimens, and have an initial virologic response but have HIV RNA levels that remain substantially >1,000 copies/mL at 36 weeks' gestation. | • Continue the current combination ARV regimen if response in HIV RNA level is appropriate.<br>• Consult an expert in HIV infection to determine the appropriateness of additional ARV agents to rapidly further decrease viral load.<br>• Recommend scheduled cesarean delivery if viral load suppression is not achieved by 38 weeks because of the potential additional benefit in preventing intrapartum HIV transmission. Inform woman about the increased maternal risks associated with cesarean delivery, including risks related to anesthesia and surgery and increased rates of postoperative infection.<br>• When the delivery method selected is scheduled cesarean, perform the procedure at 38 weeks' gestation by best obstetrical dating.<br>• When the delivery method selected is scheduled cesarean delivery, administer a 1-hour loading dose and continuous IV zidovudine for 2 hours (3 hours total) before scheduled cesarean.<br>• Continue other ARV medications on schedule, as much as possible, before and after surgery.<br>• All standard cesarean delivery management should be recommended, including the use of prophylactic antibiotics. |
| HIV-infected women on combination ARV drug regimens with undetectable HIV RNA levels at 36 weeks' gestation. | • Provide counseling on risk of perinatal transmission of HIV with a persistently undetectable HIV RNA level, which is 1% or less, even with vaginal delivery. No evidence currently exists to show that this risk can be lowered further by performing scheduled cesarean delivery.<br>• Risk of complications is increased with cesarean delivery compared with vaginal delivery, and the risks must be balanced against the uncertain benefits of cesarean delivery in women with undetectable viral load. |
| HIV-infected women with HIV RNA level >1,000 copies/mL who have elected scheduled cesarean delivery but present after rupture of membranes or onset of labor at >37 weeks' gestation. | • Start IV zidovudine immediately.<br>• Individualize the decision regarding mode of delivery based on clinical factors at presentation including duration of rupture and/or labor, plasma RNA level, and current ARV regimen. Management of vaginal delivery, if chosen, should be individualized. Some clinicians may consider administration of oxytocin, if clinically appropriate, in order to expedite delivery. Scalp electrodes and other invasive monitoring and operative delivery should be avoided, if possible, unless there are clear obstetric indications.<br>• When cesarean delivery is chosen, administration of the loading dose of IV zidovudine ideally should be completed before the procedure. |

## References


1. Committee on Obstetric Practice. ACOG committee opinion scheduled Cesarean delivery and the prevention of vertical transmission of HIV infection. Number 234, May 2000 (replaces number 219, August 1999). *Int J Gynaecol Obstet*. Jun 2001;73(3):279-281. Available at http://www.ncbi.nlm.nih.gov/pubmed/11424912.
2. European Mode of Delivery Collaboration. Elective caesarean-section versus vaginal delivery in prevention of vertical HIV-1 transmission: a randomised clinical trial. *Lancet*. Mar 27 1999;353(9158):1035-1039. Available at

http://www.ncbi.nlm.nih.gov/pubmed/10199349.

3. International Perinatal HIV Group. The mode of delivery and the risk of vertical transmission of human immunodeficiency virus type 1--a meta-analysis of 15 prospective cohort studies. The International Perinatal HIV Group. *N Engl J Med*. Apr 1 1999;340(13):977-987. Available at http://www.ncbi.nlm.nih.gov/pubmed/10099139.
4. American College of Obstetricians and Gynecologists. ACOG committee opinion. Scheduled cesarean delivery and the prevention of vertical transmission of HIV infection. Number 219, August 1999. Committee on Obstetric Practice. American College of Obstetricians and Gynecologists. *Int J Gynaecol Obstet*. Sep 1999;66(3):305-306. Available at http://www.ncbi.nlm.nih.gov/pubmed/10580685.
5. Garcia PM, Kalish LA, Pitt J, et al. Maternal levels of plasma human immunodeficiency virus type 1 RNA and the risk of perinatal transmission. Women and Infants Transmission Study Group. *N Engl J Med*. Aug 5 1999;341(6):394-402. Available at http://www.ncbi.nlm.nih.gov/pubmed/10432324.
6. Ioannidis JP, Abrams EJ, Ammann A, et al. Perinatal transmission of human immunodeficiency virus type 1 by pregnant women with RNA virus loads <1000 copies/ml. *J Infect Dis*. Feb 15 2001;183(4):539-545. Available at http://www.ncbi.nlm.nih.gov/pubmed/11170978.
7. Townsend CL, Cortina-Borja M, Peckham CS, de Ruiter A, Lyall H, Tookey PA. Low rates of mother-to-child transmission of HIV following effective pregnancy interventions in the United Kingdom and Ireland, 2000-2006. *AIDS*. May 11 2008;22(8):973-981. Available at http://www.ncbi.nlm.nih.gov/pubmed/18453857.
8. European Collaborative Study. Mother-to-child transmission of HIV infection in the era of highly active antiretroviral therapy. *Clin Infect Dis*. Feb 1 2005;40(3):458-465. Available at http://www.ncbi.nlm.nih.gov/pubmed/15668871.
9. Rodman JH, Flynn PM, Robbins B, et al. Systemic pharmacokinetics and cellular pharmacology of zidovudine in human immunodeficiency virus type 1-infected women and newborn infants. *J Infect Dis*. Dec 1999;180(6):1844-1850. Available at http://www.ncbi.nlm.nih.gov/pubmed/10558940.
10. European Collaborative Study, Patel D, Cortina-Borja M, Thorne C, Newell ML. Time to undetectable viral load after highly active antiretroviral therapy initiation among HIV-infected pregnant women. *Clin Infect Dis*. Jun 15 2007;44(12):1647-1656. Available at http://www.ncbi.nlm.nih.gov/pubmed/17516411.
11. American College of Obstetricians and Gynecologists. ACOG Practice Bulletin No. 97: Fetal lung maturity. *Obstet Gynecol*. Sep 2008;112(3):717-726. Available at http://www.ncbi.nlm.nih.gov/pubmed/18757686.
12. Tita AT, Landon MB, Spong CY, et al. Timing of elective repeat cesarean delivery at term and neonatal outcomes. *N Engl J Med*. Jan 8 2009;360(2):111-120. Available at http://www.ncbi.nlm.nih.gov/pubmed/19129525.
13. Livingston EG, Huo Y, Patel K, et al. Mode of delivery and infant respiratory morbidity among infants born to HIV-1-infected women. *Obstet Gynecol*. Aug 2010;116(2 Pt 1):335-343. Available at http://www.ncbi.nlm.nih.gov/pubmed/20664394.
14. Grubert TA, Reindell D, Kastner R, Lutz-Friedrich R, Belohradsky BH, Dathe O. Complications after caesarean section in HIV-1-infected women not taking antiretroviral treatment. *Lancet*. Nov 6 1999;354(9190):1612-1613. Available at http://www.ncbi.nlm.nih.gov/pubmed/10560681.
15. Maiques-Montesinos V, Cervera-Sanchez J, Bellver-Pradas J, Abad-Carrascosa A, Serra-Serra V. Post-cesarean section morbidity in HIV-positive women. *Acta Obstet Gynecol Scand*. Oct 1999;78(9):789-792. Available at http://www.ncbi.nlm.nih.gov/pubmed/10535342.
16. Rodriguez EJ, Spann C, Jamieson D, Lindsay M. Postoperative morbidity associated with cesarean delivery among human immunodeficiency virus-seropositive women. *Am J Obstet Gynecol*. May 2001;184(6):1108-1111. Available at http://www.ncbi.nlm.nih.gov/pubmed/11349171.
17. Semprini AE, Castagna C, Ravizza M, et al. The incidence of complications after caesarean section in 156 HIV-positive women. *AIDS*. Aug 1995;9(8):913-917. Available at http://www.ncbi.nlm.nih.gov/pubmed/7576327.
18. Urbani G, de Vries MM, Cronje HS, Niemand I, Bam RH, Beyer E. Complications associated with cesarean section in HIV-infected patients. *Int J Gynaecol Obstet*. Jul 2001;74(1):9-15. Available at

http://www.ncbi.nlm.nih.gov/pubmed/11430935.

19. Vimercati A, Greco P, Loverro G, Lopalco PL, Pansini V, Selvaggi L. Maternal complications after caesarean section in HIV infected women. *Eur J Obstet Gynecol Reprod Biol*. May 2000;90(1):73-76. Available at http://www.ncbi.nlm.nih.gov/pubmed/10767514.
20. Read JS, Newell MK. Efficacy and safety of cesarean delivery for prevention of mother-to-child transmission of HIV-1. *Cochrane Database Syst Rev*. 2005(4):CD005479. Available at http://www.ncbi.nlm.nih.gov/pubmed/16235405.
21. Faucher P, Batallan A, Bastian H, et al. [Management of pregnant women infected with HIV at Bichat Hospital between 1990 and 1998: analysis of 202 pregnancies]. *Gynecol Obstet Fertil*. Mar 2001;29(3):211-225. Available at http://www.ncbi.nlm.nih.gov/pubmed/11300046.
22. Fiore S, Newell ML, Thorne C, European HIV in Obstetrics Group. Higher rates of post-partum complications in HIV-infected than in uninfected women irrespective of mode of delivery. *AIDS*. Apr 9 2004;18(6):933-938. Available at http://www.ncbi.nlm.nih.gov/pubmed/15060441.
23. Marcollet A, Goffinet F, Firtion G, et al. Differences in postpartum morbidity in women who are infected with the human immunodeficiency virus after elective cesarean delivery, emergency cesarean delivery, or vaginal delivery. *Am J Obstet Gynecol*. Apr 2002;186(4):784-789. Available at http://www.ncbi.nlm.nih.gov/pubmed/11967508.
24. Read JS, Tuomala R, Kpamegan E, et al. Mode of delivery and postpartum morbidity among HIV-infected women: the women and infants transmission study. *J Acquir Immune Defic Syndr*. Mar 1 2001;26(3):236-245. Available at http://www.ncbi.nlm.nih.gov/pubmed/11242196.
25. Watts DH, Lambert JS, Stiehm ER, et al. Complications according to mode of delivery among human immunodeficiency virus-infected women with CD4 lymphocyte counts of ≤500/microL. *Am J Obstet Gynecol*. Jul 2000;183(1):100-107. Available at http://www.ncbi.nlm.nih.gov/pubmed/10920316.
26. International Perinatal HIV Group. Duration of ruptured membranes and vertical transmission of HIV-1: a meta-analysis from 15 prospective cohort studies. *AIDS*. Feb 16 2001;15(3):357-368. Available at http://www.ncbi.nlm.nih.gov/pubmed/11273216.
27. Jamieson DJ, Read JS, Kourtis AP, Durant TM, Lampe MA, Dominguez KL. Cesarean delivery for HIV-infected women: recommendations and controversies. *Am J Obstet Gynecol*. Sep 2007;197(3 Suppl):S96-100. Available at http://www.ncbi.nlm.nih.gov/pubmed/17825656.

## Other Intrapartum Management Considerations (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendations |
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| • The following should generally be avoided unless there are clear obstetric indications because of a potential increased risk of transmission:<br>o Artificial rupture of membranes **(BIII)**<br>o Routine use of fetal scalp electrodes for fetal monitoring **(BIII)**<br>o Operative delivery with forceps or a vacuum extractor and/or episiotomy **(BIII)** |
| • The antiretroviral drug regimen a woman is receiving should be taken into consideration when treating excessive postpartum bleeding resulting from uterine atony:<br>• In women who are receiving a cytochrome P (CYP) 3A4 enzyme inhibitor such as a protease inhibitor, methergine should be used only if no alternative treatments for postpartum hemorrhage are available and the need for pharmacologic treatment outweighs the risks. If methergine is used, it should be administered in the lowest effective dose for the shortest possible duration **(BIII)**.<br>• In women who are receiving a CYP3A4 enzyme inducer such as nevirapine, efavirenz, or etravirine, additional uterotonic agents may be needed because of the potential for decreased methergine levels and inadequate treatment effect. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*<br>***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

If spontaneous rupture of membranes occurs before or early during the course of labor, interventions to decrease the interval to delivery, such as administration of oxytocin, can be considered in HIV-infected women with viral suppression and no indications for cesarean delivery.

Artificial rupture of membranes should be avoided and used only for a clear obstetric indication in women with intact membranes and detectable viral loads who present in labor and will be allowed to proceed to vaginal delivery. Data are limited on artificial rupture of membranes in women with undetectable viral loads and planned vaginal delivery. In general, the procedure should be performed only for clear obstetrical indications because of the potential, albeit small, of an increased risk of HIV transmission.

Obstetric procedures that increase the risk of fetal exposure to maternal blood, such as invasive fetal monitoring, have been implicated in increasing vertical transmission rates by some, but not all, investigators, primarily in studies performed in the pre-antiretroviral therapy (ART) era.[1-4] Data are limited on routine use of fetal scalp electrodes in labor in women receiving suppressive antiretroviral (ARV) regimens who have undetectable viral loads; routine use of fetal scalp electrodes for fetal monitoring should be avoided in the setting of maternal HIV infection unless there are clear obstetric indications.

Similarly, data are limited to those obtained in the pre-ART era regarding the potential risk of perinatal transmission of HIV associated with operative vaginal delivery with forceps or the vacuum extractor and/or use of episiotomy.[2, 4] These procedures should be performed only if there are clear obstetric indications. Delayed cord clamping has been associated with improved iron status in both term and preterm infants and benefits such as decreased risk of intraventricular hemorrhage in preterm births to HIV-uninfected mothers.[5-8] Even though HIV-specific data on the practice are lacking, there is no reason to modify it in HIV-infected mothers.

### *Postpartum Hemorrhage, Antiretroviral Drugs, and Methergine Use*

Oral or parenteral methergine or other ergot alkaloids are often used as first-line treatment for postpartum hemorrhage resulting from uterine atony. However, methergine should not be coadministered with drugs that are potent cytochrome P (CYP) 3A4 enzyme inhibitors, including protease inhibitors (PIs). Concomitant use of ergotamines and PIs has been associated with exaggerated vasoconstrictive responses. When uterine atony results in excessive postpartum bleeding in women receiving PIs, methergine should be used only if alternative treatments such as prostaglandin F 2 alpha, misoprostol, or oxytocin are unavailable. If no alternative medications are available and the need for pharmacologic treatment outweighs the risks, methergine should be used in as low a dose and for as short a period as possible. In contrast, additional utertonic agents may be needed when other ARV drugs that are CYP3A4 inducers, such as nevirapine, efavirenz, and etravirine, are used because of the potential for decreased methergine levels and inadequate treatment effect.

## References


1. Boyer PJ, Dillon M, Navaie M, et al. Factors predictive of maternal-fetal transmission of HIV-1. Preliminary analysis of zidovudine given during pregnancy and/or delivery. *JAMA*. Jun 22-29 1994;271(24):1925-1930. Available at http://www.ncbi.nlm.nih.gov/pubmed/7911164.
2. Mandelbrot L, Mayaux MJ, Bongain A, et al. Obstetric factors and mother-to-child transmission of human immunodeficiency virus type 1: the French perinatal cohorts. SEROGEST French Pediatric HIV Infection Study Group. *Am J Obstet Gynecol*. Sep 1996;175(3 Pt 1):661-667. Available at http://www.ncbi.nlm.nih.gov/pubmed/8828431.
3. Mofenson LM, Lambert JS, Stiehm ER, et al. Risk factors for perinatal transmission of human immunodeficiency virus type 1 in women treated with zidovudine. Pediatric AIDS Clinical Trials Group Study 185 Team. *N Engl J Med*. Aug 5 1999;341(6):385-393. Available at http://www.ncbi.nlm.nih.gov/pubmed/10432323.
4. Shapiro DE, Sperling RS, Mandelbrot L, Britto P, Cunningham BE. Risk factors for perinatal human immunodeficiency virus transmission in patients receiving zidovudine prophylaxis. Pediatric AIDS Clinical Trials Group protocol 076 Study Group. *Obstet Gynecol*. Dec 1999;94(6):897-908. Available at http://www.ncbi.nlm.nih.gov/pubmed/10576173.
5. Oh W, Fanaroff AA, Carlo WA, et al. Effects of delayed cord clamping in very-low-birth-weight infants. *J Perinatol*. Apr 2011;31(Suppl 1):S68-71. Available at http://www.ncbi.nlm.nih.gov/pubmed/21448208.
6. Rabe H, Reynolds G, Diaz-Rossello J. A systematic review and meta-analysis of a brief delay in clamping the umbilical cord of preterm infants. *Neonatology*. 2008;93(2):138-144. Available at http://www.ncbi.nlm.nih.gov/pubmed/17890882.
7. Mercer JS, Vohr BR, McGrath MM, Padbury JF, Wallach M, Oh W. Delayed cord clamping in very preterm infants reduces the incidence of intraventricular hemorrhage and late-onset sepsis: a randomized, controlled trial. *Pediatrics*. Apr 2006;117(4):1235-1242. Available at http://www.ncbi.nlm.nih.gov/pubmed/16585320.
8. Andersson O, Hellstrom-Westas L, Andersson D, Domellof M. Effect of delayed versus early umbilical cord clamping on neonatal outcomes and iron status at 4 months: a randomised controlled trial. *BMJ*. 2011;343:d7157. Available at http://www.ncbi.nlm.nih.gov/pubmed/22089242.

# Postpartum Care

## Postpartum Follow-Up of HIV-Infected Women (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendations |
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| • Contraceptive counseling should be included in the prenatal period as well as immediately postpartum as a critical aspect of postpartum care **(AIII)**. |
| • Decisions about continuing antiretroviral (ARV) drugs after delivery should take into account current recommendations for initiation of antiretroviral therapy (ART), current and nadir CD4 T-lymphocyte counts and trajectory, HIV RNA levels, adherence issues, whether a woman has an HIV-uninfected sexual partner, and patient preference **(AIII)**. |
| • For women continuing ARV drugs postpartum, arrangements for new or continued supportive services should be made before hospital discharge because the immediate postpartum period poses unique challenges to adherence **(AII)**. |
| • Women with a positive rapid HIV antibody test during labor require immediate linkage to HIV care and comprehensive follow-up, including confirmation of HIV infection. If infection is confirmed, a full health assessment is warranted, including evaluation for associated medical conditions, counseling related to newly diagnosed HIV infection, and assessment of need for ART and opportunistic infection prophylaxis **(AII)**. |
| • Breastfeeding is not recommended for HIV-infected women in the United States, including those receiving ART **(AII)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

The postpartum period provides an opportunity to review and optimize women's health care. Comprehensive care and support services are particularly important for women with HIV infection and their families, who often face multiple medical and social challenges. Components of comprehensive care include the following medical and supportive care services as needed:

- primary, gynecologic/obstetric, and HIV specialty care for an HIV-infected woman;
- pediatric care for her infant;
- family planning services;
- mental health services;
- substance abuse treatment;
- support services; and
- coordination of care through case management for a woman, her child(ren), and other family members.

Support services should be tailored to individual women's needs and can include case management; child care; respite care; assistance with basic life needs, such as housing, food, and transportation; peer counseling; and legal and advocacy services. Ideally, this care should begin before pregnancy and continue throughout pregnancy and the postpartum period.

During the postpartum period, maternal medical services must be coordinated between obstetric care providers and HIV specialists. It is especially critical to ensure continuity of the antepartum antiretroviral (ARV) drug regimen when such treatment is required for a woman's health. The decision about whether to continue ARV drugs after delivery should be discussed with a woman and made before delivery.

The postpartum period also is a critical time for addressing the issue of safer sex practices, secondary transmission prevention, and contraception. It is important that comprehensive family planning and preconception care be integrated into routine health visits. Women who receive family planning counseling during prenatal care are more likely to use effective contraception postpartum.[1] Lack of breastfeeding is associated with earlier return of fertility; ovulation returns as early as 6 weeks postpartum, and even earlier in some women, putting them at risk of pregnancy shortly after delivery.[2] Interpregnancy intervals of less than 18 months have been associated with increased risk of poor perinatal and maternal outcomes in HIV-uninfected women.[3] Because of the stresses and demands of a new baby, women may be more receptive to use of effective contraception, yet simultaneously at higher risk of nonadherence to contraceptive use and, thus, unintended pregnancy.[4] This is an important concern in women who are on an efavirenz-containing regimen because of the potential risk of teratogencity in the first 5 to 6 weeks of pregnancy (the neural tube closes at 36–39 days after the last menstrual period). A "dual-protection" strategy, such as use of condoms plus a second highly effective contraceptive, is ideal for HIV-infected women because it provides simultaneous protection against unintended pregnancy, transmission of HIV, and acquisition or transmission of sexually transmitted disease.[5] Longer term reversible contraceptive methods, such as injectables, implants, and intrauterine devices (IUDs) should be included as options.

Drug interactions have been documented between oral contraceptives and many ARV drugs (see Table 4 in Preconception Counseling and Care for HIV-Infected Women of Childbearing Age); however, data primarily come from pharmacokinetic (PK) studies and the clinical implications have not been well studied. The magnitude of changes in contraceptive drug levels that may reduce contraceptive efficacy or increase contraceptive-associated adverse effects is unknown. Hormonal contraceptives can be used with antiretroviral therapy (ART) in women who have no other contraindications. Additional or alternative methods of contraception can be recommended where drug interactions are known. Estrogen-containing hormonal contraceptives significantly lower levels of amprenavir/fosamprenavir and, therefore, coadministration is not recommended. Whether low-dose ritonavir boosting raises amprenavir levels sufficiently to allow coadministration is unknown. Depot medroxyprogesterone acetate (Depo-Provera, DMPA) PKs are not significantly affected by nevirapine, efavirenz, or nelfinavir and levels of these drugs were not significantly altered by DMPA.[6] Adverse effects of DMPA are no different in HIV-infected women on ARV drugs than in HIV-uninfected women.[7] In one study, DMPA use was associated with an increase in acquisition of HIV by uninfected women and transmission of HIV from infected women to male partners, but other studies have not seen this association and further studies are needed.[8] Other non-oral contraceptives, such as levonorgestrel implants, the combined contraceptive patch, the combined hormonal contraceptive vaginal ring, and the levonorgestrel IUD, are largely unstudied in combination with ARV drugs, but some data do exist on lopinavir/ritonavir interactions with the estrogen patch.[9] ARV drug interactions may be of less concern with contraceptive methods that exert primarily local activity and have minimal systemic absorption, but there is still potential for interaction if metabolic or elimination pathways are shared.[6, 10] The World Health Organization has summarized the research on hormonal contraception, IUD use, and risk of HIV infection.[11] Permanent sterilization is appropriate only for women who are certain they do not desire future childbearing.

Decisions about whether to continue ARV drugs after delivery should be made in consultation with the HIV provider. Factors to be taken into consideration should include current recommendations for initiation of ART, current and nadir CD4-lymphocyte counts and trajectory, HIV RNA levels, adherence issues, partner HIV status, and patient preference. Women with nadir CD4 T-lymphocyte (CD4-cell) counts less than the currently recommended threshold for institution of ART[12] and/or symptomatic HIV infection should be encouraged to continue their ARV regimens postpartum without interruption. The risks versus benefits of stopping combination ART drug regimens postpartum in women with high CD4-cell counts are being evaluated in the ongoing PROMISE study (clinical trial number NCT00955968). Unplanned changes in ARV

regimens and discontinuations of ART in the postpartum period have led to viral load rebound.[4]

Recent data from the HPTN 052 clinical trial showed that earlier initiation of ARV drugs led to a significant reduction in sexual transmission of HIV to uninfected partners in serodiscordant couples (see Preconception Counseling). HPTN 052 evaluated immediate versus delayed initiation of ART to HIV-infected individuals with CD4-cell counts between 350 and 550 cells/mm$^3$. Based on the results from that trial, continued administration of ARV drugs may be recommended for prevention of sexual transmission of HIV in postpartum women who have CD4-cell counts between 350 and 550 cells/mm$^3$ and have HIV-uninfected sexual partners, and it can be considered for those with CD4-cell counts greater than 550 cells/mm$^3$ with HIV-uninfected sexual partners. It is important to counsel the woman that no single method (including treatment of the infected partner) is fully protective against HIV transmission and safer sexual practices should be continued.

Concerns have been raised about adherence to ARV regimens during the postpartum period, because a number of studies have found significant decreases in adherence postpartum.[13-16] Women should be counseled that postpartum physical and psychological changes and the stresses and demands of caring for a new baby may make adherence more difficult and that additional support may be needed during this period.[17-19] Health care providers should be vigilant for signs of depression and illicit drug or alcohol use that may require assessment and treatment and interfere with adherence. Poor adherence has been shown to be associated with virologic failure, development of resistance, and decreased long-term effectiveness of ART.[20-22] Simplification of an ARV regimen (for example, to once-daily medications) can be considered. It may be preferable to temporarily interrupt ART in women who are unable to adhere to their regimens while they work with a provider on strategies to improve adherence. Efforts to maintain adequate adherence during the postpartum period may prolong the effectiveness of therapy (see the section on *Adherence* in the *Guidelines for the Use of Antiretroviral Agents in HIV-1-Infected Adults and Adolescents*).

For women whose antepartum regimen included a non-nucleoside reverse transcriptase inhibitor (NNRTI) and who plan to stop ARV prophylaxis after delivery, consideration should be given to stopping the NNRTI and continuing the other ARV drugs for a period of time before stopping electively. The optimal interval between stopping an NNRTI and the other ARV drugs is unknown; a minimum of 7 days is recommended. Because efavirenz-based therapy has potential to result in prolonged, detectable NNRTI concentrations for more than 3 weeks, some experts recommend that patients receiving efavirenz continue their other ARV drugs or substitute a protease inhibitor (PI) for the NNRTI drug in combination with their other ARV drugs for up to 30 days after stopping efavirenz (see Stopping Antiretroviral Therapy during Pregnancy and Prevention of Antiretroviral Drug Resistance). Women whose antepartum regimen did not include an NNRTI and who plan to stop ARV prophylaxis after delivery should stop all ARV drugs at the same time. Doses of some PIs may be increased during pregnancy. For women continuing therapy, available data suggest that standard doses can be used again, beginning immediately after delivery.

Immediate linking to care, comprehensive medical assessment, counseling, and follow-up are required for women who test positive on rapid HIV antibody assay during labor or at delivery. To minimize the delay in definitive diagnosis, confirmatory HIV antibody testing should be performed as soon as possible after an initial positive rapid test.[23] Women who test positive on rapid HIV antibody assay should not breastfeed unless a confirmatory HIV test is negative. Women with a new HIV diagnosis postpartum should receive the same thorough evaluation as other newly identified infected patients, including consideration of ART and prophylaxis for opportunistic infections, as indicated. Other children and partner(s) should be referred for HIV testing.

## References

1. Jackson E. Controversies in postpartum contraception: when is it safe to start oral contraceptives after childbirth? *Thromb Res*. Feb 2011;127(Suppl 3):S35-39. Available at http://www.ncbi.nlm.nih.gov/pubmed/21262436.

2. Jackson E, Glasier A. Return of ovulation and menses in postpartum nonlactating women: a systematic review. *Obstet Gynecol*. Mar 2011;117(3):657-662. Available at http://www.ncbi.nlm.nih.gov/pubmed/21343770.

3. Sholapurkar SL. Is there an ideal interpregnancy interval after a live birth, miscarriage or other adverse pregnancy outcomes? *J Obstet Gynaecol*. Feb 2010;30(2):107-110. Available at http://www.ncbi.nlm.nih.gov/pubmed/20143964.

4. Sha BE, Tierney C, Cohn SE, et al. Postpartum viral load rebound in HIV-1-infected women treated with highly active antiretroviral therapy: AIDS Clinical Trials Group Protocol A5150. *HIV Clin Trials*. Jan-Feb 2011;12(1):9-23. Available at http://www.ncbi.nlm.nih.gov/pubmed/21388937.

5. Cates W, Jr., Steiner MJ. Dual protection against unintended pregnancy and sexually transmitted infections: what is the best contraceptive approach? *Sex Transm Dis*. Mar 2002;29(3):168-174. Available at http://www.ncbi.nlm.nih.gov/pubmed/11875378.

6. Cohn SE, Park JG, Watts DH, et al. Depo-medroxyprogesterone in women on antiretroviral therapy: effective contraception and lack of clinically significant interactions. *Clin Pharmacol Ther*. Feb 2007;81(2):222-227. Available at http://www.ncbi.nlm.nih.gov/pubmed/17192768.

7. Watts DH, Park JG, Cohn SE, et al. Safety and tolerability of depot medroxyprogesterone acetate among HIV-infected women on antiretroviral therapy: ACTG A5093. *Contraception*. Feb 2008;77(2):84-90. Available at http://www.ncbi.nlm.nih.gov/pubmed/18226670.

8. Heffron R, Donnell D, Rees H, et al. Use of hormonal contraceptives and risk of HIV-1 transmission: a prospective cohort study. *Lancet Infect Dis*. Jan 2012;12(1):19-26. Available at http://www.ncbi.nlm.nih.gov/pubmed/21975269.

9. Vogler MA, Patterson K, Kamemoto L, et al. Contraceptive efficacy of oral and transdermal hormones when co-administered with protease inhibitors in HIV-1-infected women: pharmacokinetic results of ACTG trial A5188. *J Acquir Immune Defic Syndr*. Dec 2010;55(4):473-482. Available at http://www.ncbi.nlm.nih.gov/pubmed/20842042.

10. Womack J, Williams A. Hormonal contraception in HIV-positive women. *AIDS Read*. Jul 2008;18(7):372-377, 381. Available at http://www.ncbi.nlm.nih.gov/pubmed/18655314.

11. World Health Organization. Review of Priorities in Research on Hormonal Contraception and IUDs and HIV Infection. 2010; Geneva. Available at http://whqlibdoc.who.int/hq/2010/WHO_RHR_10.21_eng.pdf. Accessed on June 29, 2012.

12. Panel on Antiretroviral Guidelines for Adults and Adolescents. Guidelines for the use of antiretroviral agents in HIV-1-infected adults and adolescents. Department of Health and Human Services. Available at http://aidsinfo.nih.gov/contentfiles/lvguidelines/AdultandAdolescentGL.pdf. Accessed on June 29, 2012.

13. Kreitchmann R, Harris DR, Kakehasi F, et al. Antiretroviral Adherence During Pregnancy and Postpartum in Latin America. *AIDS Patient Care STDS*. Jun 4 2012. Available at http://www.ncbi.nlm.nih.gov/pubmed/22663185.

14. Kaida A, Kanters S, Chaworth-Musters T, et al. Antiretroviral adherence during pregnancy and postpartum among HIV-positive women receiving highly active antiretroviral therapy (HAART) in British Columbia (BC), Canada (1997-2008). Paper presented at: 6th International AIDS Society Conference on HIV Pathogenesis, Treatment and Prevention; July 17-20, 2011; Rome, Italy. Abstract CDB397-CD-ROM.

15. Mellins CA, Chu C, Malee K, et al. Adherence to antiretroviral treatment among pregnant and postpartum HIV-infected women. *AIDS Care*. Sep 2008;20(8):958-968. Available at http://www.ncbi.nlm.nih.gov/pubmed/18608073.

16. Nachega J, Uthman C, Mills E, Muessig K, et al. Adherence to antiretroviral therapy (ART) during and after pregnancy in low, middle and high income countries: a systematic review and meta-analysis. Paper presented at: 19th Conference on Retroviruses and Opportunistic Infections (CROI); March 5-8, 2012; Seattle, WA. Abstract 1006.

17. Cohn SE, Umbleja T, Mrus J, Bardeguez AD, Andersen JW, Chesney MA. Prior illicit drug use and missed prenatal vitamins predict nonadherence to antiretroviral therapy in pregnancy: adherence analysis A5084. *AIDS Patient Care STDS*. Jan 2008;22(1):29-40. Available at http://www.ncbi.nlm.nih.gov/pubmed/18442305.

18. Ickovics JR, Wilson TE, Royce RA, et al. Prenatal and postpartum zidovudine adherence among pregnant women with HIV: results of a MEMS substudy from the Perinatal Guidelines Evaluation Project. *J Acquir Immune Defic Syndr*. Jul 1 2002;30(3):311-315. Available at http://www.ncbi.nlm.nih.gov/pubmed/12131568.

19. Bardeguez AD, Lindsey JC, Shannon M, et al. Adherence to antiretrovirals among US women during and after pregnancy. *J Acquir Immune Defic Syndr*. Aug 1 2008;48(4):408-417. Available at http://www.ncbi.nlm.nih.gov/pubmed/18614923.

20. Paterson DL, Swindells S, Mohr J, et al. Adherence to protease inhibitor therapy and outcomes in patients with HIV infection. *Ann Intern Med*. Jul 4 2000;133(1):21-30. Available at http://www.ncbi.nlm.nih.gov/pubmed/10877736.

21. Le Moing V, Chene G, Carrieri MP, et al. Clinical, biologic, and behavioral predictors of early immunologic and virologic response in HIV-infected patients initiating protease inhibitors. *J Acquir Immune Defic Syndr.* Aug 1 2001;27(4):372-376. Available at http://www.ncbi.nlm.nih.gov/pubmed/11468425.

22. Murri R, Ammassari A, Gallicano K, et al. Patient-reported nonadherence to HAART is related to protease inhibitor levels. *J Acquir Immune Defic Syndr*. Jun 1 2000;24(2):123-128. Available at http://www.ncbi.nlm.nih.gov/pubmed/10935687.

23. Centers for Disease Control and Prevention (CDC). Rapid HIV-1 antibody testing during labor and delivery for women of unknown HIV status: a practical guide and model protocol. 2004. Available at http://www.cdc.gov/hiv/topics/testing/resources/guidelines/pdf/Labor&DeliveryRapidTesting.pdf. Accessed July 3, 2012.

## Infants Born to Mothers with Unknown HIV Infection Status (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendations |
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| • For infants born to mothers with unknown HIV status, rapid HIV antibody testing of mothers and/or infants is recommended as soon as possible after birth, with immediate initiation of infant antiretroviral (ARV) prophylaxis (see Infant Antiretroviral Prophylaxis) if the rapid test is positive **(AII)**. |
| • In the setting of a positive test, standard antibody confirmatory testing such as a Western blot also should be performed on mothers (or their infants) as soon as possible. Clinicians should not wait for the results of the confirmatory test before initiating postnatal prophylaxis. If the confirmatory test is negative, ARV prophylaxis can be discontinued **(AIII)**. |
| • If the HIV antibody confirmatory test is positive, a newborn HIV DNA polymerase chain reaction (PCR) assay should be performed **(AIII)**. |
| • If the newborn HIV DNA PCR is positive, ARV prophylaxis should be discontinued and the infant promptly referred to a pediatric HIV specialist for confirmation of the diagnosis and treatment of HIV infection with standard combination antiretroviral therapy **(AI)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

Rapid HIV antibody testing of mothers and/or infants is recommended as soon as possible after birth when maternal HIV status is unknown and rapid HIV antibody testing was not performed during labor. If rapid testing is positive, infant antiretroviral (ARV) prophylaxis should be initiated immediately, without waiting for the results of a confirmatory test. Rapid HIV antibody testing should be available on a 24-hour basis at all facilities with a maternity service and/or neonatal intensive care or newborn nursery. A positive test result in mothers or infants should be presumed to indicate maternal HIV infection until standard antibody confirmatory testing clarifies maternal status. A standard confirmatory test (such as Western blot) should be performed on mothers (or their infants) as soon as possible after the initial positive rapid test.[1] A positive HIV antibody test in an infant indicates maternal but not necessarily infant HIV infection; diagnosis of HIV infection in infants younger than age 18 months requires virologic testing. If the confirmatory test on a mother (or infant) is negative, ARV prophylaxis can be discontinued. If the confirmatory test is positive, an HIV DNA polymerase chain reaction (PCR) assay should be obtained urgently from the newborn. If the HIV DNA PCR is positive, ARV prophylaxis should be promptly discontinued and the infant should receive treatment for HIV infection with standard combination antiretroviral therapy according to established *Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection*.

## Reference


1. Centers for Disease Control and Prevention (CDC). Rapid HIV-1 antibody testing during labor and delivery for women of unknown HIV status: a practical guide and model protocol. 2004; http://www.cdc.gov/hiv/topics/testing/resources/guidelines/pdf/Labor&DeliveryRapidTesting.pdf.

## Infant Antiretroviral Prophylaxis (Last updated January 29, 2013; last reviewed July 31, 2012)

| Panel's Recommendations |
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| • The 6-week neonatal component of the zidovudine chemoprophylaxis regimen is recommended for all HIV-exposed neonates to reduce perinatal transmission of HIV **(AI)**. |
| • Zidovudine, at gestational age-appropriate doses, should be initiated as close to the time of birth as possible, preferably within 6 to 12 hours of delivery **(AII)**. |
| • Infants born to HIV-infected women who have not received antepartum antiretroviral (ARV) drugs should receive prophylaxis with zidovudine given for 6 weeks combined with three doses of nevirapine in the first week of life (at birth, 48 hours later, and 96 hours after the second dose), begun as soon after birth as possible **(AI)**. |
| • In other scenarios, the decision to combine other drugs with the 6-week zidovudine regimen should be made in consultation with a pediatric HIV specialist, preferably before delivery, and should be accompanied by counseling of the mother on the potential risks and benefits of this approach **(BIII)**. |
| • In the United States, the use of ARV drugs other than zidovudine and nevirapine cannot be recommended in premature infants because of lack of dosing and safety data **(BIII)**. |
| • The National Perinatal HIV Hotline (1-888-448-8765) provides free clinical consultation on all aspects of perinatal HIV, including infant care. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

### *General Considerations for Choice of Infant Prophylaxis*

All HIV-exposed infants should receive postpartum antiretroviral (ARV) drugs to reduce perinatal transmission of HIV. The 6-week neonatal zidovudine chemoprophylaxis regimen is recommended for all HIV-exposed infants.[1, 2] Table 9 shows recommended zidovudine dosing based on the status of maternal antepartum ARV regimens. Infants born to mothers who have received standard antepartum and intrapartum ARV prophylaxis and have undetectable viral loads are at very low risk of HIV transmission and should receive the 6-week zidovudine regimen alone.

The risk of transmission is increased when maternal viral load at delivery is high or maternal antepartum and/or intrapartum prophylaxis was not received. Most experts feel that the potential benefit of combining zidovudine infant prophylaxis with additional ARV drugs may exceed the risk of multiple drug exposure to infants born to:

a. mothers who received antepartum and intrapartum ARV drugs but who had suboptimal viral suppression at delivery, particularly if delivery was vaginal;
b. mothers who received only intrapartum ARV drugs;
c. mothers who received neither antepartum nor intrapartum ARV drugs; and
d. mothers with known ARV drug-resistant virus.

In each of these situations, there is a spectrum of transmission risk that depends on a number of maternal and infant factors, including maternal viral load, mode of delivery, and gestational age at delivery. The risks and benefits of infant exposure to ARV drugs in addition to zidovudine will differ depending on where the

mother/child falls in the risk spectrum. For example, an infant delivered vaginally to a mother with an HIV RNA level ≥100,000 copies/mL at delivery has a higher risk of acquiring HIV infection than an infant born by cesarean delivery to a mother with an HIV RNA level of approximately 10,000 copies/mL at delivery. Thus, a generic recommendation cannot be made regarding use of combination drug regimens for infant prophylaxis. Each situation needs to be considered individually, balancing potential benefits (in terms of preventing perinatal transmission of HIV) with risks (in terms of toxicity to the infant). In addition, appropriate drug formulations and dosing regimens for neonates are incompletely defined and data are minimal on the safety of combination drugs in the neonate (see Short-Term Antiretroviral Drug Safety and Choice for Neonatal Prophylaxis and the *Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection*).

Recent data from the NICHD-HPTN 040/PACTG 1043 study have provided guidance for management of infants born to women who received no ARV prophylaxis during pregnancy. In this study, 1,746 infants born to HIV-infected women who did not receive any ARV drugs during pregnancy were randomized to 3 infant prophylaxis regimens: the standard 6-week zidovudine regimen; 6 weeks of zidovudine plus 3 doses of nevirapine given during the first week of life (first dose at birth–48 hours, second dose 48 hours after first dose, and third dose 96 hours after second dose); and 6 weeks of zidovudine plus 2 weeks of lamivudine/nelfinavir. The risk of intrapartum transmission was significantly lower compared with 6 weeks of zidovudine alone in the 2- and 3-drug arms (2.2% and 2.5%, respectively, vs. 4.9% for zidovudine alone; $P = .046$ for each experimental arm vs. zidovudine alone).[3] Although transmission rates with the 2 combination regimens were similar, neutropenia was significantly more common with the 3-drug regimen than with the 2-drug or zidovudine-alone regimen (27.5% vs. 15%, $P < .0001$). In other studies, significantly higher rates of neutropenia and anemia have been reported with coadministration of zidovudine and lamivudine to infants.[4] Thus, based on comparable efficacy and reduced toxicity, the Panel recommends 6 weeks of zidovudine plus 3 doses of nevirapine for infants whose mothers have not received antepartum ARVs (Table 9).

In all other scenarios, decisions about use of combination ARV prophylaxis in infants should be made in consultation with a pediatric HIV specialist before delivery, if possible, and should be accompanied by a discussion with the mothers about potential risks and benefits of this approach.

Despite the paucity of available data, the use of combination ARV prophylaxis for infants in high-risk situations is increasing. Surveillance of obstetric and pediatric HIV infection in the United Kingdom and Ireland through the National Study of HIV in Pregnancy and Childhood noted that between 2001 and 2004, 9% of HIV-exposed infants received triple-drug prophylaxis compared with 13% between 2005 and 2008.[5] Similarly, in a web-based poll of 134 U.S.-based perinatal HIV service providers, 62% reported using combination postnatal prophylaxis in high-risk situations in the past year. Zidovudine, lamivudine, and nevirapine was the combination regimen used most often.[6]

***The National Perinatal HIV Hotline (1-888-448-8765)***

The *National Perinatal HIV Hotline* is a federally funded service providing free clinical consultation to providers caring for HIV-infected pregnant women and their infants.

## *Recommendations for Infant Antiretroviral Prophylaxis in Specific Clinical Situations*

### Infants Born to Mothers Who Received Antepartum/Intrapartum Antiretroviral Drugs with Effective Viral Suppression

The risk of HIV acquisition is small in infants born to women who received standard ARV prophylaxis regimens during pregnancy and labor and had undetectable viral loads at delivery or born by scheduled cesarean section to mothers with low viral loads at delivery. Such infants should receive the 6-week

zidovudine infant prophylaxis regimen. In that situation, combining zidovudine with additional ARV drugs to reduce transmission risk is not recommended because the benefit would be very limited.

### Infants Born to Mothers Who Have Received Antepartum/Intrapartum Antiretroviral Drugs But Have Suboptimal Viral Suppression Near Delivery

The risk of perinatal transmission is related to maternal antepartum viral load in women on no ARV drugs as well as women receiving ARVs.[7-9] Scheduled cesarean delivery is recommended for prevention of perinatal transmission in women who have received antepartum ARV drugs but have detectable viremia (HIV RNA >1,000 copies/mL) near the time of delivery (see Intrapartum Care and Transmission and Mode of Delivery). In PACTG 316, transmission occurred in 0% of 17 infants when maternal HIV RNA levels at delivery were >10,000 copies/mL and delivery was by scheduled cesarean delivery.[2] However, not all women with detectable viremia near delivery will undergo cesarean delivery. The risk of acquisition of HIV will be higher in infants born to mothers with higher viral loads near delivery, particularly if delivery is vaginal. The gradient of transmission risk is based on HIV RNA levels. In the Women and Infants Transmission Study (WITS), the risk of transmission of HIV was ≤1.8% in women who received triple-combination ARV prophylaxis and had HIV RNA levels <30,000 copies/mL at delivery; it increased to 4.8% in women with HIV RNA levels ≥30,000 copies/mL.[9]

All infants should receive zidovudine for 6 weeks. No specific data address whether a more intensive combination infant prophylaxis regimen (2 or 3 drugs) provides additional protection against transmission when maternal antepartum/intrapartum prophylaxis is received but viral replication near delivery is significant. Elective cesarean section is recommended for pregnant women with HIV RNA levels >1,000 copies/mL near delivery. Extrapolation of findings from the previously discussed NICHD-HPTN 040/PACTG 1043 study[3] suggests that combination infant prophylaxis should be considered, depending on assessment of risk based on maternal viral load and mode of delivery. That decision should be made in consultation with a pediatric HIV specialist before delivery and accompanied by maternal counseling on the potential risks and benefits of this approach.

### Infants Born to Mothers Who Received Only Intrapartum Antiretroviral Drugs

All infants whose mothers have received only intrapartum ARV drugs should be given zidovudine for 6 weeks. This infant prophylaxis regimen is a critical component of prevention when no maternal antepartum ARV drugs have been received. The PETRA study demonstrated that intrapartum prophylaxis alone, without infant prophylaxis, is ineffective in reducing perinatal transmission.[10] A study in Thailand indicated that longer infant prophylaxis with zidovudine (6 weeks vs. 3 days) is required for optimal efficacy when maternal antenatal exposure to zidovudine is <4 weeks.[11] Infant prophylaxis with zidovudine should be initiated as soon after delivery as possible. In addition to zidovudine, three doses of nevirapine should be administered in the first week of life (first dose at birth–48 hours, second dose 48 hours after first dose, and third dose 96 hours after second dose). In the NICHD-HPTN 040/PACTG 043 trial previously discussed, 41% of women received zidovudine during labor. Administration of intrapartum zidovudine did not affect transmission rates.[3]

### Infants Born to Mothers Who Did Not Receive Antepartum or Intrapartum Antiretroviral Drugs

The two-drug regimen of 6 weeks of zidovudine plus three doses of nevirapine in the first week of life (first dose at birth–48 hours, second dose 48 hours after first dose, and third dose 96 hours after second dose) is recommended based on the results of the NICHD-HPTN 040/PACTG 1043 study, which demonstrated increased efficacy of combination regimens in reducing intrapartum transmission compared with use of zidovudine alone in infants.[3] Prophylaxis should be initiated as soon after delivery as possible.

The interval during which infant prophylaxis can be initiated and still be of benefit is undefined. In the New York State study, when prophylaxis was delayed beyond 48 hours after birth, no efficacy could be demonstrated. Data from animal studies indicate that the longer the delay in institution of prophylaxis, the less likely that infection will be prevented. In most studies of animals, ARV prophylaxis initiated 24 to 36 hours after exposure usually has been ineffective in preventing infection, although a delay in administration has been associated with decreased viremia.[12-14] In the NICHD-HPTN 040/PACTG 1043 study, infant regimens were initiated within 48 hours of life and usually within 12 hours of life.[3] Initiation of infant prophylaxis after age 2 days is not likely to be efficacious in preventing transmission and, by age 14 days, infection already would be established in most infants.[15] Initiating prophylaxis as soon after delivery as possible increases its potential efficacy and minimizes potential harm, such as development of resistant virus, if infection has occurred.

### Infants Born to Mothers with Antiretroviral Drug-Resistant Virus

The optimal prophylactic regimen for newborns delivered by women with ARV drug-resistant virus is unknown. ARV prophylaxis for infants born to mothers with known or suspected drug resistance should be determined in consultation with a pediatric HIV specialist before delivery.

Data from the WITS suggest that in women who have mixed zidovudine-resistant and -sensitive viral populations, the zidovudine-sensitive rather than -resistant virus may be preferentially transmitted.[16, 17] Thus, the 6-week infant zidovudine prophylaxis (along with maternal intravenous intrapartum zidovudine prophylaxis) continues to be recommended, even when maternal zidovudine-resistant virus with thymidine-associated mutations is identified.

Some studies have suggested that ARV drug-resistant virus may have decreased replicative capacity (reduced viral fitness) and transmissibility.[17] However, transmission from mother to child of multidrug-resistant virus has been reported.[18-20]

For these newborns, use of zidovudine in combination with other ARV drugs, selected on the basis of maternal virus resistance testing, should be considered. The efficacy of this approach for prevention of transmission, however, has not been proven in clinical trials, and for many drugs, appropriate dosing regimens for neonates have not been established. Decisions regarding use of additional drugs should be made in consultation with a pediatric HIV specialist and will depend on maternal history of past and current ARV drug exposure, HIV RNA levels at or near delivery, current and previous maternal resistance testing, and availability of drug formulation and dosing information in the infant.

## *Short-Term Antiretroviral Drug Safety and Choice for Neonatal Prophylaxis*

Infant prophylaxis with zidovudine has been associated with only minimal toxicity, consisting primarily of transient hematologic toxicity (mainly anemia), which generally resolves by age 12 weeks (see Initial Postnatal Management). Data are limited on the toxicity to infants of exposure to multiple ARV drugs.

The latest information on neonatal dosing for ARV drugs can be found in the *Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection*. Other than zidovudine, lamivudine is the nucleoside reverse transcriptase inhibitor (NRTI) with the most experience in use for neonatal prophylaxis. In early studies, neonatal exposure to combination zidovudine/lamivudine was generally limited to 1[10, 21, 22] or 2 weeks.[3] Six weeks of infant zidovudine/lamivudine exposure also has been reported; these studies suggest that hematologic toxicity may be increased over that seen with zidovudine alone, although the infants also had *in utero* exposure to maternal combination therapy.

In a French study, more severe anemia and neutropenia were observed in infants exposed to 6 weeks of zidovudine/lamivudine for prophylaxis plus maternal antepartum zidovudine/lamivudine than in a historical

cohort exposed only to maternal and infant zidovudine. Anemia was reported in 15% and neutropenia in 18% of infants exposed to zidovudine/lamivudine, with 2% of infants requiring blood transfusion and 4% requiring treatment discontinuation for toxicity.[4] Similarly, in a Brazilian study of maternal antepartum and 6-week infant zidovudine/lamivudine prophylaxis, neonatal hematologic toxicity was common, with anemia seen in 69% and neutropenia in 13% of infants.[23]

Experience with other NRTI drugs for neonatal prophylaxis is more limited.[24, 25] Hematologic and mitochondrial toxicity may be more common with exposure to multiple versus single NRTI drugs.[4, 26-29]

Nevirapine is the only non-nucleoside reverse transcriptase inhibitor drug with a pediatric drug formulation and neonatal dosing information (see *Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection*).[30] In rare cases, chronic multiple-dose nevirapine has been associated with severe and potentially life-threatening rash and hepatic toxicity. These toxicities have not been observed in infants receiving single-dose nevirapine, the two-drug zidovudine regimen plus three doses of nevirapine in the first week of life in NICHD-HPTN 040/PACTG 1043), or in breastfeeding infants receiving nevirapine prophylaxis daily for 6 weeks to 6 months to prevent transmission of HIV via breast milk.[3, 31-34] Resistance to nevirapine can occur, however, with exposure to nevirapine in infants who become infected despite prophylaxis.[35, 36] ARV drug-resistance testing is recommended for all HIV-infected infants before initiation of antiretroviral therapy (see *Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection*).

Of the protease inhibitors (PIs), although nelfinavir, lopinavir/ritonavir, ritonavir, tipranavir, and fosamprenavir have pediatric drug formulations, their use in neonates is not recommended. Pharmacokinetic (PK) studies of nelfinavir in newborn infants show highly variable plasma concentrations and no single dose that results in safe but adequate nelfinavir concentrations in all infants has been defined.[25, 37, 38] In addition, nelfinavir powder is no longer commercially available in the United States. No PK data are available for the other PIs in infants in the first 2 weeks of life. PK data are available for treatment of HIV-infected infants 2 to 6 weeks of age with lopinavir/ritonavir. Although the lopinavir area under the curve (AUC) was significantly lower with dosing 300 mg lopinavir/75 mg ritonavir/$m^2$ body surface area twice daily than observed for infants >6 weeks of age, treatment was well tolerated and 80% of 10 infants had viral control at 6 months.[39] Studies are ongoing but data are not yet available for infants <2 weeks of age. However, in 4 premature infants (2 sets of twins) started on lopinavir/ritonavir from birth, heart block developed that resolved after drug discontinuation.[40, 41] In studies of adults, both ritonavir and lopinavir/ritonavir cause dose-dependent prolongation of the PR interval, and cases of significant heart block, including complete heart block, have been reported. Elevation of 17-hydroxyprogesterone and dehydroepiandrosterone-sulfate has also been associated with administration of lopinavir/ritonavir compared with zidovudine in the neonatal period. Levels of 17-hydroxyprogesterone were greater in infants who were also exposed to lopinavir/ritonavir *in utero* compared with those exposed only in the neonatal period. Term infants were asymptomatic but 3 premature newborns experienced life-threatening symptoms compatible with adrenal insufficiency, including hyponatremia and hyperkalemia with, in 1 case, cardiogenic shock.[42] Based on these and other post-marketing reports of cardiac toxicity (including complete atrioventricular block, bradycardia, and cardiomyopathy), lactic acidosis, acute renal failure, adrenal dysfunction, central nervous system depression, respiratory complications leading to death, and metabolic toxicity,[43] predominantly in preterm neonates, the Food and Drug Administration now recommends that lopinavir/ritonavir NOT be administered to neonates before a postmenstrual age (first day of the mother's last menstrual period to birth plus the time elapsed after birth) of 42 weeks and a postnatal age of at least 14 days.

## *Neonatal Antiretroviral Drug Dosing*

**Table 9. Recommended Neonatal Dosing for Prevention of Mother-to-Child Transmission of HIV**

| All HIV-Exposed Infants (initiated as soon after delivery as possible) | | |
|---|---|---|
| **Zidovudine (ZDV)** | **Dosing** | **Duration** |
| ZDV | **≥35 weeks' gestation at birth:** 4 mg/kg/dose PO twice daily, started as soon after birth as possible and preferably within 6–12 hours of delivery (or, if unable to tolerate oral agents, 3 mg/kg/dose IV, beginning within 6–12 hours of delivery, then every 12 hours) | Birth through 6 weeks |
| ZDV | **≥30 to <35 weeks' gestation at birth:** 2 mg/kg/dose PO (or 1.5 mg/kg/dose IV), started as soon after birth as possible, preferably within 6–12 hours of delivery, then every 12 hours, advanced to 3 mg/kg/dose PO (or 2.3 mg/kg/dose IV) every 12 hours at age 15 days | Birth through 6 weeks |
| ZDV | **<30 weeks' gestation at birth:** 2 mg/kg body weight/dose PO (or 1.5 mg/kg/dose IV) started as soon after birth as possible, preferably within 6–12 hours of delivery, then every 12 hours, advanced to 3 mg/kg/dose PO (or 2.3 mg/kg/dose IV) every 12 hours after age 4 weeks | Birth through 6 weeks |
| **Additional Antiretroviral Prophylaxis Agents for HIV-Exposed Infants of Women who Received No Antepartum Antiretroviral Prophylaxis (initiated as soon after delivery as possible)** | | |
| In addition to ZDV as shown above, administer<br>**Nevirapine (NVP)** | **Weight Band Dosing**<br>**Birth weight 1.5-2 kg: 8 mg TOTAL for each dose**<br>**Birth weight >2 kg: 12 mg TOTAL for each dose** | 3 doses in the first week of life<br>• 1st dose within 48 hours of birth (birth–48 hours)<br>• 2nd dose 48 hours after 1st<br>• 3rd dose 96 hours after 2nd |

**Key to Abbreviations:** IV = intravenously; NVP = nevirapine; PO = orally; ZDV = zidovudine

The recommended dose of zidovudine for post-exposure prophylaxis in full-term neonates is 4 mg/kg body weight orally (PO) twice daily for the first 6 weeks of life, beginning as soon after birth as possible and preferably within 6 to 12 hours of delivery.[10, 31, 44-51] (Table 9) If the infant is unable to tolerate oral medications, the 6-week zidovudine prophylaxis regimen can be administered intravenously (IV). The zidovudine dosing requirements differ for premature infants and term infants (see Antiretroviral Drug Dosing for Premature Infants).

In the United Kingdom and many other European countries, a 4-week neonatal chemoprophylaxis regimen is recommended for infants born to mothers who have received antenatal combination ARV drug regimens.[52, 53] This approach also can be considered in cases where adherence to or toxicity from the 6-week zidovudine prophylaxis regimen is a concern. In an Irish observational study, a transmission rate of 1.1% was observed in 916 infants who received 4 weeks of zidovudine infant prophylaxis following antenatal maternal combination ARV prophylaxis. That is the standard regimen in Ireland and the transmission rate was similar to that observed in the United States, where 6 weeks of infant zidovudine prophylaxis is standard.[53] A prospective, observational study reported that the 4-week zidovudine regimen allowed earlier recovery from anemia in otherwise healthy infants compared with the 6-week zidovudine regimen.[54] The optimal duration

of neonatal zidovudine chemoprophylaxis, however, has not been established in clinical trials, and in the United States, the standard 6-week infant zidovudine regimen is recommended unless there are concerns about adherence or toxicity. Consultation with an expert in pediatric HIV infection is advised if early discontinuation of prophylaxis is considered.

PKs and safety of the single-dose nevirapine regimen to mother and infant[55] and chronic nevirapine administration to infants to prevent HIV transmission during breastfeeding have been studied.[56] The 3-dose extended nevirapine regimen that was used in NICHD-HPTN 040/PACTG 1043 and is recommended for HIV-exposed infants whose mothers did not receive ARV during the antepartum period has also been studied.[30] In the NICHD-HPTN 040/PACTG 1043 study, nevirapine concentrations were measured in 14 newborns participating in a PK substudy during the second week of life and in single samples from 30 more newborns on Days 10 to 14. The median nevirapine elimination half-life was 30.2 hours (range: 17.8–50.3 hours) and the concentration remained greater than the target of 100 ng/mL in all infants through Day 10 of life.[30]

### Antiretroviral Drug Dosing for Premature Infants

Dosing recommendations for premature infants is available for only zidovudine and nevirapine (see Table 9). Zidovudine is primarily cleared through hepatic glucuronidation to an inactive metabolite; this metabolic pathway is immature in neonates, leading to prolonged zidovudine half-life and clearance compared with older infants. Clearance is further prolonged in premature infants because their hepatic metabolic function is even less mature than in term infants.[57, 58] The recommended zidovudine dosage for infants less than 35 weeks' gestation at birth is 2 mg/kg body weight per dose PO every 12 hours (or 1.5 mg/kg/dose IV every 12 hours), increasing to 3 mg/kg/dose PO (or 2.3 mg/kg/dose IV) every 12 hours at age 15 days. For infants born at less than 30 weeks' gestation, 2 mg/kg/dose PO (or 1.5 mg/kg/dose IV) started as soon after birth as possible, preferably within 6 to 12 hours of delivery, then every 12 hours, advanced to 3 mg/kg/dose PO (or 2.3 mg/kg/dose IV) every 12 hours after age 4 weeks is recommended.

PKs in low birth weight infants receiving a single dose of nevirapine have been described. In a study of 81 infants less than 37 weeks' gestation, of which 29.6% were small for gestational age, half-lives were very long—median 59 hours in infants whose mothers received single-dose nevirapine and 69 hours in infants whose mothers did not receive single-dose nevirapine. AUC of nevirapine was higher and clearance lower ($P < .0001$) in small-for-gestational-age infants.[59]

Use of ARV drugs other than zidovudine and nevirapine cannot be recommended at this time in premature infants because data on dosing and safety are lacking. Immature renal and hepatic metabolism can increase the risk of overdosing and toxicity. However, in situations where there is a high risk of infant HIV infection, consultation with a pediatric HIV specialist is recommended to determine if the benefits of combination ARV prophylaxis other than zidovudine and nevirapine outweigh the potential risks.

### Breastfeeding Infants of Mothers Diagnosed with HIV Infection Postpartum

Breastfeeding should be stopped until infection is confirmed or ruled out in women who are breastfeeding at the time of HIV diagnosis or suspected to be HIV infected. Pumping and temporarily discarding breast milk can be recommended to mothers who are suspected of being HIV infected but whose infection is not yet confirmed and who want to continue to breastfeed. If HIV infection is ruled out, breastfeeding can resume.

The risk of acquisition of HIV associated with breastfeeding depends on multiple infant and maternal factors, including maternal viral load and CD4 T-lymphocyte (CD4-cell) count.[60] Infants of women who develop acute HIV infection while breastfeeding are at greater risk of becoming infected than are those of women with chronic HIV infection[61] because acute HIV infection is accompanied by a rapid increase in viral load and a corresponding decrease in CD4-cell count.[62]

Other than discontinuing breastfeeding, optimal strategies for managing infants born to HIV-infected mothers

who breastfed their infants before HIV diagnosis have yet to be defined. Some experts would consider the use of post-exposure prophylaxis in infants for 4 to 6 weeks after cessation of breastfeeding. Post-exposure prophylaxis, however, is less likely to be effective in this circumstance compared with other nonoccupational exposures because the exposure to breast milk is likely to have occurred over a prolonged period rather than in a single exposure.[63]

Several studies of infants breastfed by women with chronic HIV infection have shown that daily infant nevirapine or nevirapine plus zidovudine can reduce the risk of postnatal infection during breastfeeding.[31-33] The NICHD-HPTN 040/PACTG 043 study demonstrated that combination ARV prophylaxis was more effective than zidovudine prophylaxis alone for preventing intrapartum transmission in mothers who have not received antepartum ARV drugs.[3] However, whether the combination regimens in this trial are effective for preventing transmission after cessation of breastfeeding in mothers with acute HIV infection is unknown.

An alternative approach favored by some experts would be to offer a combination ARV regimen that would be effective for treatment of HIV should the infant become infected. If this route is chosen, current recommendations for treatment should guide selection of an appropriate combination ARV regimen (see *Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection*). Regardless of whether post-exposure prophylaxis or "preemptive therapy" is chosen, the optimal duration of the intervention is unknown. A 28-day course may be reasonable based on current recommendations for nonoccupational HIV exposure.[63] As in other situations, decisions regarding administration of a prophylactic or preemptive treatment regimen should be accompanied by consultation with a pediatric HIV specialist and maternal counseling on the potential risks and benefits of this approach.

Infants should be tested for HIV infection at baseline and 4 to 6 weeks, 3 months, and 6 months after recognition of maternal infection to determine HIV status. In infants younger than age 18 months, HIV DNA or RNA polymerase chain reaction (PCR) tests should be used for diagnosis. HIV DNA PCR is preferable for infants who are receiving combination ARV prophylaxis or preemptive treatment. HIV antibody assays can be used in infants older than age 18 months. Post-exposure ARV prophylaxis or preemptive treatment should be discontinued in infants who are found to be HIV infected while receiving one of these regimens. Resistance testing then should be performed and an appropriate combination therapy regimen initiated (see *Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection*).

## References


1. Connor EM, Sperling RS, Gelber R, et al. Reduction of maternal-infant transmission of human immunodeficiency virus type 1 with zidovudine treatment. Pediatric AIDS Clinical Trials Group Protocol 076 Study Group. *N Engl J Med*. Nov 3 1994;331(18):1173-1180. Available at http://www.ncbi.nlm.nih.gov/pubmed/7935654.
2. Dorenbaum A, Cunningham CK, Gelber RD, et al. Two-dose intrapartum/newborn nevirapine and standard antiretroviral therapy to reduce perinatal HIV transmission: a randomized trial. *JAMA*. Jul 10 2002;288(2):189-198. Available at http://www.ncbi.nlm.nih.gov/pubmed/12095383.
3. Nielsen-Saines K, Watts DH, Veloso VG, et al. Three postpartum antiretroviral regimens to prevent intrapartum HIV infection. *N Engl J Med*. Jun 21 2012;366(25):2368-2379. Available at http://www.ncbi.nlm.nih.gov/pubmed/22716975.
4. Mandelbrot L, Landreau-Mascaro A, Rekacewicz C, et al. Lamivudine-zidovudine combination for prevention of maternal-infant transmission of HIV-1. *JAMA*. Apr 25 2001;285(16):2083-2093. Available at http://www.ncbi.nlm.nih.gov/pubmed/11311097.
5. Haile-Selassie H, Townsend C, Tookey P. Use of neonatal post-exposure prophylaxis for prevention of mother-to-child HIV transmission in the UK and Ireland, 2001-2008. *HIV Med*. Aug 2011;12(7):422-427. Available at http://www.ncbi.nlm.nih.gov/pubmed/21251184.

6. McKeegan K, Rutstein R, Lowenthal E. Postnatal infant HIV prophylaxis: a survey of U.S. practice. *AIDS Patient Care STDS*. Jan 2011;25(1):1-4. Available at http://www.ncbi.nlm.nih.gov/pubmed/21162689.

7. Mofenson LM, Lambert JS, Stiehm ER, et al. Risk factors for perinatal transmission of human immunodeficiency virus type 1 in women treated with zidovudine. Pediatric AIDS Clinical Trials Group Study 185 Team. *N Engl J Med*. Aug 5 1999;341(6):385-393. Available at http://www.ncbi.nlm.nih.gov/pubmed/10432323.

8. Garcia PM, Kalish LA, Pitt J, et al. Maternal levels of plasma human immunodeficiency virus type 1 RNA and the risk of perinatal transmission. Women and Infants Transmission Study Group. *N Engl J Med*. Aug 5 1999;341(6):394-402. Available at http://www.ncbi.nlm.nih.gov/pubmed/10432324.

9. Cooper ER, Charurat M, Mofenson L, et al. Combination antiretroviral strategies for the treatment of pregnant HIV-1-infected women and prevention of perinatal HIV-1 transmission. *J Acquir Immune Defic Syndr*. Apr 15 2002;29(5):484-494. Available at http://www.ncbi.nlm.nih.gov/pubmed/11981365.

10. Petra Study Team. Efficacy of three short-course regimens of zidovudine and lamivudine in preventing early and late transmission of HIV-1 from mother to child in Tanzania, South Africa, and Uganda (Petra study): a randomised, double-blind, placebo-controlled trial. *Lancet*. Apr 6 2002;359(9313):1178-1186. Available at http://www.ncbi.nlm.nih.gov/pubmed/11955535.

11. Lallemant M, Jourdain G, Le Coeur S, et al. A trial of shortened zidovudine regimens to prevent mother-to-child transmission of human immunodeficiency virus type 1. Perinatal HIV Prevention Trial (Thailand) Investigators. *N Engl J Med*. Oct 5 2000;343(14):982-991. Available at http://www.ncbi.nlm.nih.gov/pubmed/11018164.

12. Van Rompay KK, Otsyula MG, Marthas ML, Miller CJ, McChesney MB, Pedersen NC. Immediate zidovudine treatment protects simian immunodeficiency virus-infected newborn macaques against rapid onset of AIDS. *Antimicrob Agents Chemother*. Jan 1995;39(1):125-131. Available at http://www.ncbi.nlm.nih.gov/pubmed/7695293.

13. Tsai CC, Follis KE, Sabo A, et al. Prevention of SIV infection in macaques by (R)-9-(2-phosphonylmethoxypropyl)adenine. *Science*. Nov 17 1995;270(5239):1197-1199. Available at http://www.ncbi.nlm.nih.gov/pubmed/7502044.

14. Bottiger D, Johansson NG, Samuelsson B, et al. Prevention of simian immunodeficiency virus, SIVsm, or HIV-2 infection in cynomolgus monkeys by pre- and postexposure administration of BEA-005. *AIDS*. Feb 1997;11(2):157-162. Available at http://www.ncbi.nlm.nih.gov/pubmed/9030361.

15. Dunn DT, Brandt CD, Krivine A, et al. The sensitivity of HIV-1 DNA polymerase chain reaction in the neonatal period and the relative contributions of intra-uterine and intra-partum transmission. *AIDS*. Sep 1995;9(9):F7-11. Available at http://www.ncbi.nlm.nih.gov/pubmed/8527070.

16. Colgrove RC, Pitt J, Chung PH, Welles SL, Japour AJ. Selective vertical transmission of HIV-1 antiretroviral resistance mutations. *AIDS*. Dec 3 1998;12(17):2281-2288. Available at http://www.ncbi.nlm.nih.gov/pubmed/9863870.

17. Bauer GR, Colgrove RC, Larussa PS, Pitt J, Welles SL. Antiretroviral resistance in viral isolates from HIV-1-transmitting mothers and their infants. *AIDS*. Aug 22 2006;20(13):1707-1712. Available at http://www.ncbi.nlm.nih.gov/pubmed/16931934.

18. Cohan D, Feakins C, Wara D, et al. Perinatal transmission of multidrug-resistant HIV-1 despite viral suppression on an enfuvirtide-based treatment regimen. *AIDS*. Jun 10 2005;19(9):989-990. Available at http://www.ncbi.nlm.nih.gov/pubmed/15905684.

19. Desai N, Mathur M. Selective transmission of multidrug resistant HIV to a newborn related to poor maternal adherence. *Sex Transm Infect*. Oct 2003;79(5):419-421. Available at http://www.ncbi.nlm.nih.gov/pubmed/14573842.

20. De Jose MI, Ramos JT, Alvarez S, Jimenez JL, Munoz-Fernandez MA. Vertical transmission of HIV-1 variants resistant to reverse transcriptase and protease inhibitors. *Arch Intern Med*. Dec 10-24 2001;161(22):2738-2739. Available at http://www.ncbi.nlm.nih.gov/pubmed/11732941.

21. Moodley J, Moodley D, Pillay K, et al. Pharmacokinetics and antiretroviral activity of lamivudine alone or when coadministered with zidovudine in human immunodeficiency virus type 1-infected pregnant women and their offspring.

*J Infect Dis*. Nov 1998;178(5):1327-1333. Available at http://www.ncbi.nlm.nih.gov/pubmed/9780252.

22. Moodley D, Moodley J, Coovadia H, et al. A multicenter randomized controlled trial of nevirapine versus a combination of zidovudine and lamivudine to reduce intrapartum and early postpartum mother-to-child transmission of human immunodeficiency virus type 1. *J Infect Dis*. Mar 1 2003;187(5):725-735. Available at http://www.ncbi.nlm.nih.gov/pubmed/12599045.
23. Lambert JS, Nogueira SA, Abreu T, et al. A pilot study to evaluate the safety and feasibility of the administration of AZT/3TC fixed dose combination to HIV infected pregnant women and their infants in Rio de Janeiro, Brazil. *Sex Transm Infect*. Dec 2003;79(6):448-452. Available at http://www.ncbi.nlm.nih.gov/pubmed/14663118.
24. Gray G, Violari A, McIntyre J, et al. Antiviral activity of nucleoside analogues during short-course monotherapy or dual therapy: its role in preventing HIV infection in infants. *J Acquir Immune Defic Syndr*. Jun 2006;42(2):169-176. Available at http://www.ncbi.nlm.nih.gov/pubmed/16639342.
25. Rongkavilit C, van Heeswijk RP, Limpongsanurak S, et al. Dose-escalating study of the safety and pharmacokinetics of nelfinavir in HIV-exposed neonates. *J Acquir Immune Defic Syndr*. Apr 15 2002;29(5):455-463. Available at http://www.ncbi.nlm.nih.gov/pubmed/11981361.
26. Torres SM, Walker DM, Carter MM, et al. Mutagenicity of zidovudine, lamivudine, and abacavir following in vitro exposure of human lymphoblastoid cells or in utero exposure of CD-1 mice to single agents or drug combinations. *Environ Mol Mutagen*. Apr-May 2007;48(3-4):224-238. Available at http://www.ncbi.nlm.nih.gov/pubmed/17358033.
27. Le Chenadec J, Mayaux MJ, Guihenneuc-Jouyaux C, Blanche S, Enquete Perinatale Francaise Study Group. Perinatal antiretroviral treatment and hematopoiesis in HIV-uninfected infants. *AIDS*. Sep 26 2003;17(14):2053-2061. Available at http://www.ncbi.nlm.nih.gov/pubmed/14502008.
28. Pacheco SE, McIntosh K, Lu M, et al. Effect of perinatal antiretroviral drug exposure on hematologic values in HIV-uninfected children: An analysis of the women and infants transmission study. *J Infect Dis*. Oct 15 2006;194(8):1089-1097. Available at http://www.ncbi.nlm.nih.gov/pubmed/16991083.
29. Feiterna-Sperling C, Weizsaecker K, Buhrer C, et al. Hematologic effects of maternal antiretroviral therapy and transmission prophylaxis in HIV-1-exposed uninfected newborn infants. *J Acquir Immune Defic Syndr*. May 1 2007;45(1):43-51. Available at http://www.ncbi.nlm.nih.gov/pubmed/17356471.
30. Mirochnick M, Nielsen-Saines K, Pilotto JH, et al. Nevirapine concentrations in newborns receiving an extended prophylactic regimen. *J Acquir Immune Defic Syndr*. Mar 1 2008;47(3):334-337. Available at http://www.ncbi.nlm.nih.gov/pubmed/18398973.
31. Kumwenda NI, Hoover DR, Mofenson LM, et al. Extended antiretroviral prophylaxis to reduce breast-milk HIV-1 transmission. *N Engl J Med*. Jul 10 2008;359(2):119-129. Available at http://www.ncbi.nlm.nih.gov/pubmed/18525035.
32. Six Week Extended-Dose Nevirapine Study Team, Bedri A, Gudetta B, et al. Extended-dose nevirapine to 6 weeks of age for infants to prevent HIV transmission via breastfeeding in Ethiopia, India, and Uganda: an analysis of three randomised controlled trials. *Lancet*. Jul 26 2008;372(9635):300-313. Available at http://www.ncbi.nlm.nih.gov/pubmed/18657709.
33. Chasela CS, Hudgens MG, Jamieson DJ, et al. Maternal or infant antiretroviral drugs to reduce HIV-1 transmission. *N Engl J Med*. Jun 17 2010;362(24):2271-2281. Available at http://www.ncbi.nlm.nih.gov/pubmed/20554982.
34. Coovadia HM, Brown ER, Fowler MG, et al. Efficacy and safety of an extended nevirapine regimen in infant children of breastfeeding mothers with HIV-1 infection for prevention of postnatal HIV-1 transmission (HPTN 046): a randomised, double-blind, placebo-controlled trial. *Lancet*. Jan 21 2012;379(9812):221-228. Available at http://www.ncbi.nlm.nih.gov/pubmed/22196945.
35. Moorthy A, Gupta A, Bhosale R, et al. Nevirapine resistance and breast-milk HIV transmission: effects of single and extended-dose nevirapine prophylaxis in subtype C HIV-infected infants. *PLoS One*. 2009;4(1):e4096. Available at http://www.ncbi.nlm.nih.gov/pubmed/19119321.

36. Fogel J, Hoover DR, Sun J, et al. Analysis of nevirapine resistance in HIV-infected infants who received extended nevirapine or nevirapine/zidovudine prophylaxis. *AIDS*. Apr 24 2011;25(7):911-917. Available at http://www.ncbi.nlm.nih.gov/pubmed/21487249.

37. Mirochnick M, Stek A, Acevedo M, et al. Safety and pharmacokinetics of nelfinavir coadministered with zidovudine and lamivudine in infants during the first 6 weeks of life. *J Acquir Immune Defic Syndr*. Jun 1 2005;39(2):189-194. Available at http://www.ncbi.nlm.nih.gov/pubmed/15905735.

38. Mirochnick M, Nielsen-Saines K, Pilotto JH, et al. Nelfinavir and Lamivudine pharmacokinetics during the first two weeks of life. *Pediatr Infect Dis J*. Sep 2011;30(9):769-772. Available at http://www.ncbi.nlm.nih.gov/pubmed/21666540.

39. Chadwick EG, Pinto J, Yogev R, et al. Early initiation of lopinavir/ritonavir in infants less than 6 weeks of age: pharmacokinetics and 24-week safety and efficacy. *Pediatr Infect Dis J*. Mar 2009;28(3):215-219. Available at http://www.ncbi.nlm.nih.gov/pubmed/19209098.

40. Lopriore E, Rozendaal L, Gelinck LB, Bokenkamp R, Boelen CC, Walther FJ. Twins with cardiomyopathy and complete heart block born to an HIV-infected mother treated with HAART. *AIDS*. Nov 30 2007;21(18):2564-2565. Available at http://www.ncbi.nlm.nih.gov/pubmed/18025905.

41. McArthur MA, Kalu SU, Foulks AR, Aly AM, Jain SK, Patel JA. Twin preterm neonates with cardiac toxicity related to lopinavir/ritonavir therapy. *Pediatr Infect Dis J*. Dec 2009;28(12):1127-1129. Available at http://www.ncbi.nlm.nih.gov/pubmed/19820426.

42. Simon A, Warszawski J, Kariyawasam D, et al. Association of prenatal and postnatal exposure to lopinavir-ritonavir and adrenal dysfunction among uninfected infants of HIV-infected mothers. *JAMA*. Jul 6 2011;306(1):70-78. Available at http://www.ncbi.nlm.nih.gov/pubmed/21730243.

43. Boxwell D, Cao K, Lewis L, Marcus K, Nikhar B. Neonatal toxicity of Kaletra oral solution: LPV, ethanol or prophylene glycol? Paper presented at: 18th Conference on Retroviruses and Opportunistic Infections (CROI); February 27-Mar 2, 2011; Boston, MA. Abstract 708.

44. Taha TE, Kumwenda NI, Hoover DR, et al. Nevirapine and zidovudine at birth to reduce perinatal transmission of HIV in an African setting: a randomized controlled trial. *JAMA*. Jul 14 2004;292(2):202-209. Available at http://www.ncbi.nlm.nih.gov/pubmed/15249569.

45. Taha TE, Kumwenda NI, Gibbons A, et al. Short postexposure prophylaxis in newborn babies to reduce mother-to-child transmission of HIV-1: NVAZ randomised clinical trial. *Lancet*. Oct 11 2003;362(9391):1171-1177. Available at http://www.ncbi.nlm.nih.gov/pubmed/14568737.

46. Shapiro RL, Thior I, Gilbert PB, et al. Maternal single-dose nevirapine versus placebo as part of an antiretroviral strategy to prevent mother-to-child HIV transmission in Botswana. *AIDS*. Jun 12 2006;20(9):1281-1288. Available at http://www.ncbi.nlm.nih.gov/pubmed/16816557.

47. Gray GE, Urban M, Chersich MF, et al. A randomized trial of two postexposure prophylaxis regimens to reduce mother-to-child HIV-1 transmission in infants of untreated mothers. *AIDS*. Aug 12 2005;19(12):1289-1297. Available at http://www.ncbi.nlm.nih.gov/pubmed/16052084.

48. Kilewo C, Karlsson K, Ngarina M, et al. Prevention of mother-to-child transmission of HIV-1 through breastfeeding by treating mothers with triple antiretroviral therapy in Dar es Salaam, Tanzania: the Mitra Plus study. *J Acquir Immune Defic Syndr*. Nov 1 2009;52(3):406-416. Available at http://www.ncbi.nlm.nih.gov/pubmed/19730269.

49. Peltier CA, Ndayisaba GF, Lepage P, et al. Breastfeeding with maternal antiretroviral therapy or formula feeding to prevent HIV postnatal mother-to-child transmission in Rwanda. *AIDS*. Nov 27 2009;23(18):2415-2423. Available at http://www.ncbi.nlm.nih.gov/pubmed/19730349.

50. Shapiro RL, Hughes MD, Ogwu A, et al. Antiretroviral regimens in pregnancy and breast-feeding in Botswana. *N Engl J Med*. Jun 17 2010;362(24):2282-2294. Available at http://www.ncbi.nlm.nih.gov/pubmed/20554983.

51. Kesho Bora Study Group, de Vincenzi I. Triple antiretroviral compared with zidovudine and single-dose nevirapine prophylaxis during pregnancy and breastfeeding for prevention of mother-to-child transmission of HIV-1 (Kesho Bora study): a randomised controlled trial. *Lancet Infect Dis*. Mar 2011;11(3):171-180. Available at http://www.ncbi.nlm.nih.gov/pubmed/21237718.

52. de Ruiter A, Mercey D, Anderson J, et al. British HIV Association and Children's HIV Association guidelines for the management of HIV infection in pregnant women 2008. *HIV Med*. Aug 2008;9(7):452-502. Available at http://www.ncbi.nlm.nih.gov/pubmed/18840151.

53. Ferguson W, Goode M, Walsh A, Gavin P, Butler K. Evaluation of 4 weeks' neonatal antiretroviral prophylaxis as a component of a prevention of mother-to-child transmission program in a resource-rich setting. *Pediatr Infect Dis J*. May 2011;30(5):408-412. Available at http://www.ncbi.nlm.nih.gov/pubmed/21266939.

54. Lahoz R, Noguera A, Rovira N, et al. Antiretroviral-related hematologic short-term toxicity in healthy infants: implications of the new neonatal 4-week zidovudine regimen. *Pediatr Infect Dis J*. Apr 2010;29(4):376-379. Available at http://www.ncbi.nlm.nih.gov/pubmed/19949355.

55. Mirochnick M, Dorenbaum A, Blanchard S, et al. Predose infant nevirapine concentration with the two-dose intrapartum neonatal nevirapine regimen: association with timing of maternal intrapartum nevirapine dose. *J Acquir Immune Defic Syndr*. Jun 1 2003;33(2):153-156. Available at http://www.ncbi.nlm.nih.gov/pubmed/12794547.

56. Shetty AK, Coovadia HM, Mirochnick MM, et al. Safety and trough concentrations of nevirapine prophylaxis given daily, twice weekly, or weekly in breast-feeding infants from birth to 6 months. *J Acquir Immune Defic Syndr*. Dec 15 2003;34(5):482-490. Available at http://www.ncbi.nlm.nih.gov/pubmed/14657758.

57. Capparelli EV, Mirochnick M, Dankner WM, et al. Pharmacokinetics and tolerance of zidovudine in preterm infants. *J Pediatr*. Jan 2003;142(1):47-52. Available at http://www.ncbi.nlm.nih.gov/pubmed/12520254.

58. Mirochnick M, Capparelli E, Connor J. Pharmacokinetics of zidovudine in infants: a population analysis across studies. *Clin Pharmacol Ther*. Jul 1999;66(1):16-24. Available at http://www.ncbi.nlm.nih.gov/pubmed/10430105.

59. Mugabo P, Els I, Smith J, et al. Nevirapine plasma concentrations in premature infants exposed to single-dose nevirapine for prevention of mother-to-child transmission of HIV-1. *S Afr Med J*. Sep 2011;101(9):655-658. Available at http://www.ncbi.nlm.nih.gov/pubmed/21920159.

60. Kuhn L, Reitz C, Abrams EJ. Breastfeeding and AIDS in the developing world. *Curr Opin Pediatr*. Feb 2009;21(1):83-93. Available at http://www.ncbi.nlm.nih.gov/pubmed/19242244.

61. Van de Perre P, Lepage P, Homsy J, Dabis F. Mother-to-infant transmission of human immunodeficiency virus by breast milk: presumed innocent or presumed guilty? *Clin Infect Dis*. Sep 1992;15(3):502-507. Available at http://www.ncbi.nlm.nih.gov/pubmed/1445596.

62. Daar ES. Virology and immunology of acute HIV type 1 infection. *AIDS Res Hum Retroviruses*. Oct 1998;14(Suppl 3):S229-234. Available at http://www.ncbi.nlm.nih.gov/pubmed/9814948.

63. Smith DK, Grohskopf LA, Black RJ, et al. Antiretroviral postexposure prophylaxis after sexual, injection-drug use, or other nonoccupational exposure to HIV in the United States: recommendations from the U.S. Department of Health and Human Services. *MMWR Recomm Rep*. Jan 21 2005;54(RR-2):1-20. Available at http://www.ncbi.nlm.nih.gov/pubmed/15660015.

## Initial Postnatal Management of the HIV-Exposed Neonate (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendations |
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| • A complete blood count and differential should be performed on newborns as a baseline evaluation **(BIII)**. |
| • Decisions about the timing of subsequent monitoring of hematologic parameters in infants depend on baseline hematologic values, gestational age at birth, clinical condition of the infants, the zidovudine dose being administered, receipt of other ARV drugs and concomitant medications, and maternal antepartum ARV therapy **(CIII)**. |
| • If hematologic abnormalities are identified in infants receiving prophylaxis, decisions on whether to continue infant antiretroviral (ARV) prophylaxis need to be individualized. Consultation with an expert in pediatric HIV infection is advised if early discontinuation of prophylaxis is considered **(CIII)**. |
| • Some experts recommend more intensive monitoring of hematologic and serum chemistry and liver function assays at birth and when diagnostic HIV polymerase chain reaction tests are obtained in infants exposed to combination ARV drug regimens *in utero* or during the neonatal period **(CIII)**. |
| • A recheck of hemoglobin and neutrophil counts is recommended 4 weeks after initiation of prophylaxis for infants who receive combination zidovudine/lamivudine-containing ARV prophylaxis regimens **(AI)**. |
| • Routine measurement of serum lactate is not recommended. However, measurement can be considered if an infant develops severe clinical symptoms of unknown etiology (particularly neurologic symptoms) **(CIII)**. |
| • Virologic tests are required to diagnose HIV infection in infants <18 months of age and should be performed within the first 14 to 21 days of life, at 1 to 2 months, and at 4 to 6 months of age **(AII)**. |
| • To prevent *Pneumocystis jirovecii* pneumonia (PCP), all infants born to women with HIV infection should begin PCP prophylaxis at ages 4 to 6 weeks, after completing their ARV prophylaxis regimen, unless there is adequate test information to presumptively exclude HIV infection (see USPHS/IDSA Guidelines for the Prevention and Treatment of Opportunistic Infections in HIV-Exposed and Infected Children) **(AII)**. |
| • Health care providers should routinely inquire about premastication of foods fed to infants, instruct HIV-infected caregivers to avoid this practice, and advise on safer feeding options **(AII)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional* |
| ***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

A complete blood count (CBC) and differential should be performed on HIV-exposed newborns before initiation of infant antiretroviral (ARV) drug prophylaxis. Decisions about the timing of hematologic monitoring of infants after birth depend on a number of factors, including baseline hematologic values, gestational age at birth, clinical condition of the infants, which ARV drugs are being administered, receipt of concomitant medications, and maternal antepartum ARV drug regimen. Anemia is the primary complication seen in neonates given the standard 6-week postnatal zidovudine regimen. In PACTG 076, infants in the zidovudine group had lower hemoglobin at birth than those in the placebo group, with the maximal difference (1 g/dL) occurring at age 3 weeks.[1] The lowest mean value for hemoglobin levels (10 g/dL) occurred at age 6 weeks in the zidovudine group. By age 12 weeks, hemoglobin values in both groups were similar. No significant differences in other laboratory parameters were observed between groups.

Some experts recheck hematologic values in healthy infants receiving zidovudine prophylaxis only if symptoms are present. Hematologic safety data are limited on administration of 4 mg/kg of zidovudine twice

daily in infants. When administering this dosing regimen, some experts recheck hemoglobin and neutrophil counts routinely after 4 weeks of zidovudine prophylaxis and/or when diagnostic HIV polymerase chain reaction (PCR) tests are obtained.

*In utero* exposure to maternal combination ARV drug regimens may be associated with some increase in anemia and/or neutropenia compared with that seen in infants exposed to zidovudine alone.[2-5] In PACTG 316, where 77% of mothers received antenatal combination therapy, significant Grade 3 or higher anemia was noted in 13% and neutropenia in 12% of infants, respectively. Depending on the combination regimen the mother has received, some experts advise more intensive laboratory monitoring, including serum chemistry and transaminases at birth plus a CBC at the time of diagnostic HIV PCR testing; monitoring of bilirubin levels may be considered for infants exposed antenatally to atazanavir.

In addition, data are limited on infants receiving zidovudine in combination with other ARVs for prophylaxis. However, higher rates of hematologic toxicity have been observed in infants receiving zidovudine/lamivudine combination prophylaxis compared with those receiving zidovudine alone or zidovudine plus nevirapine.[6] A recheck of hemoglobin and neutrophil counts, therefore, is recommended for infants who receive combination zidovudine/lamivudine-containing ARV prophylaxis regimens 4 weeks after initiation of prophylaxis and/or at the time that diagnostic HIV PCR testing is done.[7]

If hematologic abnormalities are found, decisions on whether to continue infant ARV prophylaxis need to be individualized. Considerations include the extent of the abnormality, whether related symptoms are present, duration of infant prophylaxis, risk of HIV infection (as assessed by the mother's history of ARV prophylaxis, viral load near delivery, and mode of delivery), and the availability of alternative interventions such as erythropoietin and transfusion. Consideration can be given to reducing the duration of infant prophylaxis from 6 to 4 weeks, as is the case in many European centers. In a recent prospective, observational study, the 4-week regimen was found to allow earlier recovery from anemia in otherwise healthy infants compared with the 6-week regimen.[8] Consultation with an expert in pediatric HIV infection is advised if discontinuation of prophylaxis is considered.

Hyperlactatemia has been reported in infants with *in utero* exposure to ARVs, but it appears to be transient and, in most cases, asymptomatic.[9, 10] Routine measurement of serum lactate is not recommended in asymptomatic neonates to assess for potential mitochondrial toxicity because the clinical relevance is unknown and the predictive value for toxicity appears poor.[9, 10] Serum lactate measurement should be considered, however, for infants who develop severe clinical symptoms of unknown etiology, particularly neurologic symptoms. In infants with symptoms, if the levels are significantly abnormal (>5 mmol/L), ARV prophylaxis should be discontinued and an expert in pediatric HIV infection should be consulted regarding potential alternate prophylaxis.

To prevent *Pneumocystis jirovecii* pneumonia, all infants born to women with HIV infection should begin trimethoprim-sulfamethoxazole prophylaxis at age 6 weeks, after completion of the infant ARV prophylaxis regimen, unless there is adequate virologic test information to presumptively exclude HIV infection (see *USPHS/IDSA Guidelines for the Prevention and Treatment of Opportunistic Infections in HIV-Exposed and Infected Children*).[11]

HIV infection in infants should be diagnosed using HIV DNA PCR or RNA virologic assays. Maternal HIV antibody crosses the placenta and will be detectable in all HIV-exposed infants up to age 18 months; therefore, standard antibody tests should not be used for HIV diagnosis in newborns. HIV virologic testing should be performed within the first 14 to 21 days of life, at 1 to 2 months, and at 4 to 6 months of age.[12] Some experts also perform a virologic test at birth, especially in women who have not had good virologic control during pregnancy or if adequate follow-up of the infant may not be assured. A positive HIV virologic test should be confirmed as soon as possible with a second HIV virologic test on a different specimen. Two

positive HIV tests constitute a diagnosis of HIV infection. Data do not indicate any delay in HIV diagnosis with HIV DNA PCR assays in infants who have received the zidovudine regimen.[1, 13] However, the effect of maternal or infant exposure to combination ARV drug regimens on the sensitivity of infant virologic diagnostic testing—particularly using HIV RNA assays—is unknown. Therefore, although HIV RNA assays may be acceptable for diagnosis (particularly in older infants), HIV DNA PCR assays may be optimal for diagnosing infection in the neonatal period. Any newly diagnosed infant should undergo viral resistance testing by genotype and/or phenotype to assess for susceptibility to combination antiretroviral therapy.

HIV may be presumptively excluded with two or more negative tests, one at age 14 days or older and the other at age 1 month or older. Definitive exclusion of HIV in non-breastfed infants can be based on two negative virologic tests at age 1 month or older and at age 4 months or older. Many experts confirm HIV-negative status with an HIV antibody test at ages 12 to 18 months. Alternative algorithms exist for presumptive and definitive HIV exclusion.[12] This testing algorithm applies mainly to exposure to HIV subtype B, which is the predominant viral subtype found in the United States. Non-subtype B viruses predominate in some other parts of the world. Non-subtype B infection may not be detected by many commercially available nucleic acid tests, particularly HIV DNA PCR. Many of the newer HIV RNA assays have improved detection of non-subtype B HIV, but there are still variants that are either poorly detected or undetectable. If non-subtype B HIV infection is suspected based on maternal origins, then newer HIV RNA assays that have improved ability to detect non-subtype B HIV should be used as part of the initial diagnostic algorithm. Exposed infants also should be closely monitored and undergo definitive HIV serologic testing at age 18 months (see the *Guidelines for the Use of Antiretroviral Agents in Pediatric HIV Infection, Issues Related to Diagnosis of Non-Subtype B HIV Infection* for additional information).

Following birth, HIV-exposed infants should have a detailed physical examination, and a thorough maternal history should be obtained. HIV-infected mothers may be coinfected with other pathogens that can be transmitted from mother to child, such as cytomegalovirus, herpes simplex virus, hepatitis B, hepatitis C, syphilis, toxoplasmosis, or tuberculosis. Infants born to mothers with such coinfections should undergo appropriate evaluation, as indicated by maternal CD4 T-lymphocyte count and evidence of disease activity, to rule out transmission of additional infectious agents. The routine primary immunization schedule should be followed for HIV-exposed infants born to HIV-infected mothers. Modifications in the schedule for live virus vaccines may be required for infants with known HIV infection (see *USPHS/IDSA Guidelines for the Prevention and Treatment of Opportunistic Infections in HIV-Exposed and Infected Children*).

### *Infant Feeding Practices and Risk of HIV Transmission*

In the United States, where safe infant feeding alternatives are available and free for women in need, HIV-infected women should not breastfeed their infants. Maternal receipt of combination ARV regimens is likely to reduce free virus in the breast milk, but the presence of cell-associated virus (intracellular HIV DNA) remains unaffected and, therefore, may continue to pose a transmission risk.[14]

Late HIV transmission events in infancy have been reported in HIV-infected children suspected of acquiring HIV infection as a result of consuming premasticated food given to them by their caregivers. Phylogenetic comparisons of virus from cases and suspected sources and supporting clinical history and investigations identified the practice of feeding premasticated foods to infants as a potential risk factor for HIV transmission. Health care providers should routinely inquire about premastication, instruct HIV-infected caregivers against this feeding practice, and advise on safer feeding options.[15, 16]

## References

1. Connor EM, Sperling RS, Gelber R, et al. Reduction of maternal-infant transmission of human immunodeficiency virus type 1 with zidovudine treatment. Pediatric AIDS Clinical Trials Group Protocol 076 Study Group. *N Engl J Med*. Nov

3 1994;331(18):1173-1180. Available at http://www.ncbi.nlm.nih.gov/pubmed/7935654.

2. Feiterna-Sperling C, Weizsaecker K, Buhrer C, et al. Hematologic effects of maternal antiretroviral therapy and transmission prophylaxis in HIV-1-exposed uninfected newborn infants. *J Acquir Immune Defic Syndr*. May 1 2007;45(1):43-51. Available at http://www.ncbi.nlm.nih.gov/pubmed/17356471.
3. El Beitune P, Duarte G. Antiretroviral agents during pregnancy: consequences on hematologic parameters in HIV-exposed, uninfected newborn infant. *Eur J Obstet Gynecol Reprod Biol*. Sep-Oct 2006;128(1-2):59-63. Available at http://www.ncbi.nlm.nih.gov/pubmed/16876310.
4. Watson WJ, Stevens TP, Weinberg GA. Profound anemia in a newborn infant of a mother receiving antiretroviral therapy. *Pediatr Infect Dis J*. May 1998;17(5):435-436. Available at http://www.ncbi.nlm.nih.gov/pubmed/9613665.
5. Dryden-Peterson S, Shapiro RL, Hughes MD, et al. Increased risk of severe infant anemia after exposure to maternal HAART, Botswana. *J Acquir Immune Defic Syndr*. Apr 15 2011;56(5):428-436. Available at http://www.ncbi.nlm.nih.gov/pubmed/21266910.
6. Nielsen-Saines K, Watts DH, Veloso VG, et al. Three postpartum antiretroviral regimens to prevent intrapartum HIV infection. *N Engl J Med*. Jun 21 2012;366(25):2368-2379. Available at http://www.ncbi.nlm.nih.gov/pubmed/22716975.
7. Mandelbrot L, Landreau-Mascaro A, Rekacewicz C, et al. Lamivudine-zidovudine combination for prevention of maternal-infant transmission of HIV-1. *JAMA*. Apr 25 2001;285(16):2083-2093. Available at http://www.ncbi.nlm.nih.gov/pubmed/11311097.
8. Lahoz R, Noguera A, Rovira N, et al. Antiretroviral-related hematologic short-term toxicity in healthy infants: implications of the new neonatal 4-week zidovudine regimen. *Pediatr Infect Dis J*. Apr 2010;29(4):376-379. Available at http://www.ncbi.nlm.nih.gov/pubmed/19949355.
9. Ekouevi DK, Toure R, Becquet R, et al. Serum lactate levels in infants exposed peripartum to antiretroviral agents to prevent mother-to-child transmission of HIV: Agence Nationale de Recherches Sur le SIDA et les Hepatites Virales 1209 study, Abidjan, Ivory Coast. *Pediatrics*. Oct 2006;118(4):e1071-1077. Available at http://www.ncbi.nlm.nih.gov/pubmed/16950945.
10. Noguera A, Fortuny C, Munoz-Almagro C, et al. Hyperlactatemia in human immunodeficiency virus-uninfected infants who are exposed to antiretrovirals. *Pediatrics*. Nov 2004;114(5):e598-603. Available at http://www.ncbi.nlm.nih.gov/pubmed/15492359.
11. Mofenson LM, Brady MT, Danner SP, et al. Guidelines for the Prevention and Treatment of Opportunistic Infections among HIV-exposed and HIV-infected children: recommendations from CDC, the National Institutes of Health, the HIV Medicine Association of the Infectious Diseases Society of America, the Pediatric Infectious Diseases Society, and the American Academy of Pediatrics. *MMWR Recomm Rep*. Sep 4 2009;58(RR-11):1-166. Available at http://www.ncbi.nlm.nih.gov/pubmed/19730409.
12. Schneider E, Whitmore S, Glynn KM, et al. Revised surveillance case definitions for HIV infection among adults, adolescents, and children aged <18 months and for HIV infection and AIDS among children aged 18 months to <13 years—United States, 2008. *MMWR Recomm Rep*. Dec 5 2008;57(RR-10):1-12. Available at http://www.ncbi.nlm.nih.gov/pubmed/19052530.
13. Kovacs A, Xu J, Rasheed S, et al. Comparison of a rapid nonisotopic polymerase chain reaction assay with four commonly used methods for the early diagnosis of human immunodeficiency virus type 1 infection in neonates and children. *Pediatr Infect Dis J*. Nov 1995;14(11):948-954. Available at http://www.ncbi.nlm.nih.gov/pubmed/8584360.
14. Gaillard P, Fowler MG, Dabis F, et al. Use of antiretroviral drugs to prevent HIV-1 transmission through breast-feeding: from animal studies to randomized clinical trials. *J Acquir Immune Defic Syndr*. Feb 1 2004;35(2):178-187. Available at http://www.ncbi.nlm.nih.gov/pubmed/14722452.
15. Ivy W, 3rd, Dominguez KL, Rakhmanina NY, et al. Premastication as a route of pediatric HIV transmission: case-control and cross-sectional investigations. *J Acquir Immune Defic Syndr*. Feb 1 2012;59(2):207-212. Available at http://www.ncbi.nlm.nih.gov/pubmed/22027873.

16. Gaur AH, Dominguez KL, Kalish ML, et al. Practice of feeding premasticated food to infants: a potential risk factor for HIV transmission. *Pediatrics*. Aug 2009;124(2):658-666. Available at http://www.ncbi.nlm.nih.gov/pubmed/19620190.

## Long-Term Follow-Up of Antiretroviral Drug-Exposed Infants (Last updated July 31, 2012; last reviewed July 31, 2012)

| Panel's Recommendations |
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| • Children with *in utero*/neonatal exposure to antiretroviral (ARV) drugs who develop significant organ system abnormalities of unknown etiology, particularly of the nervous system or heart, should be evaluated for potential mitochondrial dysfunction **(CIII)**.<br>• Follow-up of children with exposure to ARVs should continue into adulthood because of the theoretical concerns regarding the potential for carcinogenicity of nucleoside analogue ARV drugs **(CIII)**. |
| ***Rating of Recommendations:*** *A = Strong; B = Moderate; C = Optional*<br>***Rating of Evidence:*** *I = One or more randomized trials with clinical outcomes and/or validated laboratory endpoints; II = One or more well-designed, nonrandomized trials or observational cohort studies with long-term clinical outcomes; III = Expert opinion* |

Data remain insufficient to address the effect that exposure to zidovudine or other antiretroviral (ARV) agents *in utero* might have on long-term risk of neoplasia or organ system toxicities in children. Data from follow-up of PACTG 076 infants through age 6 years do not indicate any differences in immunologic, neurologic, and growth parameters between infants who were exposed to the zidovudine regimen and those who received placebo, and no malignancies have been seen.[1-3] As discussed earlier in NRTI Drugs and Mitochondrial Toxicity, data are conflicting regarding whether mitochondrial dysfunction is associated with perinatal exposure to ARVs. Children with *in utero* exposure to ARVs who develop significant organ system abnormalities of unknown etiology, particularly of the nervous system or heart, should be evaluated for potential mitochondrial dysfunction.[4-6] Follow-up of children with exposure to ARVs should continue into adulthood because of the theoretical concerns regarding the potential for carcinogenicity of the nucleoside analogue ARV drugs. Long-term follow-up should include annual physical examinations of all children exposed to ARV drugs. Innovative methods are needed to provide follow-up of infants with *in utero* exposure to ARV drugs. Information regarding such exposure should be part of ongoing permanent medical records for children, particularly those who are uninfected.

Evaluation is ongoing of early and late effects of *in utero* exposure to ARVs, including the Pediatric HIV/AIDS Cohort Study, Surveillance Monitoring of Antiretroviral Toxicity Study, natural history studies, and HIV/AIDS surveillance conducted by state health departments and the Centers for Disease Control and Prevention. Because most of the available follow-up data relate to *in utero* exposure to antenatal zidovudine alone and most HIV-infected pregnant women currently receive combination ARV drug regimens, it is critical that studies to evaluate potential adverse effects of *in utero* drug exposure continue to be supported. HIV surveillance databases from states that require HIV reporting provide an opportunity to collect population-based information concerning *in utero* exposure to ARVs. To the extent permitted by federal law and regulations, data from these confidential registries can be compared with information from birth defect and cancer registries to identify potential adverse outcomes.

## References


1. Culnane M, Fowler M, Lee SS, et al. Lack of long-term effects of *in utero* exposure to zidovudine among uninfected children born to HIV-infected women. Pediatric AIDS Clinical Trials Group Protocol 219/076 Teams. *JAMA*. Jan 13 1999;281(2):151-157. Available at http://www.ncbi.nlm.nih.gov/pubmed/9917118.
2. Hanson IC, Antonelli TA, Sperling RS, et al. Lack of tumors in infants with perinatal HIV-1 exposure and fetal/neonatal exposure to zidovudine. *J Acquir Immune Defic Syndr Hum Retrovirol*. Apr 15 1999;20(5):463-467. Available at

http://www.ncbi.nlm.nih.gov/pubmed/10225228.

3. Brogly S, Williams P, Seage GR, 3rd, Van Dyke R. *In utero* nucleoside reverse transcriptase inhibitor exposure and cancer in HIV-uninfected children: an update from the pediatric AIDS clinical trials group 219 and 219C cohorts. *J Acquir Immune Defic Syndr*. Apr 1 2006;41(4):535-536. Available at http://www.ncbi.nlm.nih.gov/pubmed/16652068.
4. Blanche S, Tardieu M, Rustin P, et al. Persistent mitochondrial dysfunction and perinatal exposure to antiretroviral nucleoside analogues. *Lancet*. Sep 25 1999;354(9184):1084-1089. Available at http://www.ncbi.nlm.nih.gov/pubmed/10509500.
5. Barret B, Tardieu M, Rustin P, et al. Persistent mitochondrial dysfunction in HIV-1-exposed but uninfected infants: clinical screening in a large prospective cohort. *AIDS*. Aug 15 2003;17(12):1769-1785. Available at http://www.ncbi.nlm.nih.gov/pubmed/12891063.
6. Spector SA, Saitoh A. Mitochondrial dysfunction: prevention of HIV-1 mother-to-infant transmission outweighs fear. *AIDS*. Aug 22 2006;20(13):1777-1778. Available at http://www.ncbi.nlm.nih.gov/pubmed/16931943.

# Supplement: Safety and Toxicity of Individual Antiretroviral Agents in Pregnancy

## Nucleoside and Nucleotide Analogue Reverse Transcriptase Inhibitors

| Glossary of Terms for Supplement |
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| **Carcinogenic** = producing or tending to produce cancer<br>• Some agents, such as certain chemicals or forms of radiation, are both mutagenic and clastogenic.<br>• Genetic mutations and/or chromosomal damage can contribute to cancer formation. |
| **Clastogenic** = causing disruption of or breakages in chromosomes |
| **Genotoxic** = damaging to genetic material such as DNA and chromosomes |
| **Mutagenic** = inducing or capable of inducing genetic mutation |
| **Teratogenic** = interfering with fetal development and resulting in birth defects |

Six nucleoside analogue reverse transcriptase inhibitors (nucleoside NRTIs) and one nucleotide reverse transcriptase inhibitor (nucleotide NRTI) are currently approved (zalcitabine is no longer available in the United States). Data are available from clinical trials in human pregnancy for the nucleoside NRTIs zidovudine, abacavir, lamivudine, didanosine, emtricitabine, and stavudine and the nucleoside NRTI tenofovir. The nucleoside analogue drugs require three intracellular phosphorylation steps to form the triphosphate nucleoside, which is the active drug moiety. Tenofovir, an acyclic nucleotide analogue drug, contains a monophosphate component attached to the adenine base and, hence, requires only two phosphorylation steps to form the active moiety.

For information regarding the nucleoside analogue drug class and potential mitochondrial toxicity in pregnancy and to the infant, see NRTI Drugs and Mitochondrial Toxicity in the perinatal guidelines.

***Abacavir (Ziagen, ABC)*** is classified as Food and Drug Administration (FDA) Pregnancy Category C.
**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Abacavir is mutagenic and clastogenic in some *in vitro* and *in vivo* assays. In long-term carcinogenicity studies in mice and rats, malignant tumors of the preputial gland of males and the clitoral gland of females were observed in both species, and malignant hepatic tumors and nonmalignant hepatic and thyroid tumors were observed in female rats. The tumors were seen in rodents at doses that were 6 to 32 times that of human therapeutic exposure.
- Reproduction/fertility
  No effect of abacavir on reproduction or fertility in male and female rodents has been seen at doses of up to 500 mg/kg/day (about 8 times that of human therapeutic exposure based on body surface area).
- Teratogenicity/developmental toxicity
  Abacavir is associated with developmental toxicity (decreased fetal body weight and reduced crown-rump length) and increased incidence of fetal anasarca and skeletal malformations in rats treated with abacavir during organogenesis at doses of 1000 mg/kg (about 35 times that of human therapeutic exposure based on area under the curve [AUC]). Toxicity to the developing embryo and fetus (increased resorptions and decreased fetal body weight) occurred with abacavir administration of 500 mg/kg/day to

pregnant rodents. The offspring of female rats were treated with 500 mg/kg of abacavir, beginning at embryo implantation and ending at weaning. In these animals, an increased incidence of stillbirth and lower body weight was seen throughout life. However, in the rabbit, no evidence of drug-related developmental toxicity was observed and no increase in fetal malformations was observed at doses up to 700 mg/kg (about 8.5 times that of human therapeutic exposure).

In the Antiretroviral Pregnancy Registry, sufficient numbers of first-trimester exposures to abacavir in humans have been monitored to be able to detect at least a 2-fold increase in risk of overall birth defects. No such increase in birth defects has been observed with abacavir. Among cases of first-trimester abacavir exposure reported to the Antiretroviral Pregnancy Registry, the prevalence of birth defects was 3.0% (25 of 823 births; 95% confidence interval [CI], 2.0%–4.5%) compared with 2.7% in the U.S. population, based on Centers for Disease Control and Prevention (CDC) surveillance.[1]

- Placental and breast milk passage
  Abacavir crosses the placenta and is excreted into the breast milk of lactating rats.
- Human studies in pregnancy
  A Phase I study of abacavir in pregnant women indicates that the AUC drug concentration during pregnancy was similar to that at 6 to 12 weeks postpartum and in non-pregnant individuals.[2] Thus, no dose adjustment for abacavir is needed during pregnancy. Serious hypersensitivity reactions have been associated with abacavir therapy in non-pregnant adults and have rarely been fatal; symptoms include fever, skin rash, fatigue, and gastrointestinal symptoms such as nausea, vomiting, diarrhea, or abdominal pain. Abacavir should not be restarted following a hypersensitivity reaction because more severe symptoms will occur within hours and may include life-threatening hypotension and death.

## References


1. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
2. Best BM, Mirochnick M, Capparelli EV, et al. Impact of pregnancy on abacavir pharmacokinetics. *AIDS*. Feb 28 2006;20(4):553-560. Available at http://www.ncbi.nlm.nih.gov/pubmed/16470119.


***Didanosine (Videx, ddI)*** is classified as FDA Pregnancy Category B.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Didanosine is both mutagenic and clastogenic in several *in vitro* and *in vivo* assays. Long-term animal carcinogenicity screening studies at human exposures of 0.7 to 1.7 times in mice and 3 times in rats have been negative.
- Reproduction/fertility
  At approximately 12 times the estimated human exposure, didanosine was slightly toxic to female rats and their pups during mid and late lactation. These rats showed reduced food intake and body weight gains; however, the physical and functional development of the offspring was not impaired and there were no major changes in the F2 generation.
- Teratogenicity/developmental toxicity
  No evidence of teratogenicity or toxicity was observed with administration of didanosine at 12 and 14 times human exposure, respectively, in pregnant rats and rabbits. Among cases of first-trimester didanosine exposure reported to the Antiretroviral Pregnancy Registry, prevalence of birth defects was

4.6% (19 of 409 births; 95% CI, 2.8%–7.2%) compared with 2.7% in the U.S. population, based on CDC surveillance.[1] All defects were reviewed in detail by the Registry, and no pattern of defects was discovered. The rate and types of defects will continue to be closely monitored.

- Placental and breast milk passage
  Placental transfer of didanosine was limited in a Phase I/II safety and pharmacokinetic (PK) study.[2] This was confirmed in a study of 100 HIV-infected pregnant women who were receiving NRTIs (generally as part of a two- or three-drug combination antiretroviral [ARV] regimen). At the time of delivery, cord-to-maternal blood ratio for didanosine (n = 10) was 0.38 (range 0.0–2.0) and in 15 of 24 (62%) samples, cord blood concentrations for didanosine were below the limits of detection.[3] A study in rats showed that didanosine and/or its metabolites are transferred to the fetus through the placenta. It is not known if didanosine is excreted in human breast milk.

- Human studies in pregnancy
  A Phase I study (PACTG 249) of didanosine was conducted in 14 HIV-infected pregnant women enrolled at gestational age 26 to 36 weeks and treated through 6 weeks postpartum.[2] The drug was well tolerated during pregnancy by the women and the fetuses. PK parameters after oral administration were not significantly affected by pregnancy, and dose modification from the usual adult dosage is not needed.

  Lactic acidosis, in some cases fatal, has been described in pregnant women receiving the combination of didanosine and stavudine along with other ARV agents;[4-6] the FDA and Bristol-Myers Squibb have issued a warning to health care professionals that pregnant women may be at increased risk of fatal lactic acidosis when prescribed didanosine and stavudine in combination. These two drugs should be prescribed together to pregnant women only when the potential benefit clearly outweighs the potential risk. Clinicians should prescribe this ARV combination in pregnancy with caution and generally only when other nucleoside analog drug combinations have failed or have caused unacceptable toxicity or side effects.

## References


1. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
2. Wang Y, Livingston E, Patil S, et al. Pharmacokinetics of didanosine in antepartum and postpartum human immunodeficiency virus—infected pregnant women and their neonates: an AIDS clinical trials group study. *J Infect Dis*. 1999;180(5):1536-1541. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=10515813.
3. Chappuy H, Treluyer JM, Jullien V, et al. Maternal-fetal transfer and amniotic fluid accumulation of nucleoside analogue reverse transcriptase inhibitors in human immunodeficiency virus-infected pregnant women. *Antimicrob Agents Chemother*. Nov 2004;48(11):4332-4336. Available at http://www.ncbi.nlm.nih.gov/pubmed/15504861.
4. Mandelbrot L, Kermarrec N, Marcollet A, et al. Case report: nucleoside analogue-induced lactic acidosis in the third trimester of pregnancy. *AIDS*. Jan 24 2003;17(2):272-273. Available at http://www.ncbi.nlm.nih.gov/pubmed/12545093.
5. Sarner L, Fakoya A. Acute onset lactic acidosis and pancreatitis in the third trimester of pregnancy in HIV-1 positive women taking antiretroviral medication. *Sex Transm Infect*. Feb 2002;78(1):58-59. Available at http://www.ncbi.nlm.nih.gov/pubmed/11872862.
6. Bristol-Myers Squibb Company. Healthcare Provider Important Drug Warning Letter. January 5, 2001. Available at http://www.fda.gov/Safety/MedWatch/SafetyInformation/SafetyAlertsforHumanMedicalProducts/ucm173947.htm. Accessed on June 25, 2012.

***Emtricitabine (Emtriva, FTC)*** is classified as FDA Pregnancy Category B.
**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Emtricitabine was neither mutagenic nor clastogenic in a series of *in vitro* and animal *in vivo* screening tests. In long-term oral carcinogenicity studies of emtricitabine, no drug-related increases in tumor incidence were found in mice at doses up to 26 times the human systemic exposure at a therapeutic dose of 200 mg/day or in rats at doses up to 31 times the human systemic exposure at the therapeutic dose.

- Reproduction/fertility
  No effect of emtricitabine on reproduction or fertility was observed with doses that produced systemic drug exposures (as measured by AUC) approximately 60-fold higher in female mice and 140-fold higher in male mice than observed with human exposure at the recommended therapeutic dose.

- Teratogenicity/developmental toxicity
  Incidence of fetal variations and malformations was not increased with emtricitabine dosing in mice that resulted in systemic drug exposure 60-fold higher than observed with human exposure at recommended doses or in rabbits with dosing resulting in drug exposure 120-fold higher than human exposure.

  In the Antiretroviral Pregnancy Registry, sufficient numbers of first-trimester exposures to emtricitabine in humans have been monitored to be able to detect at least a 2-fold increase in risk of overall birth defects. No such increase in birth defects has been observed with emtricitabine. Among cases of first-trimester emtricitabine exposure reported to the Antiretroviral Pregnancy Registry, the prevalence of birth defects was 2.3% (21 of 899 births; 95% CI, 1.4%–3.5%) compared with a 2.7% total prevalence in the U.S. population, based on CDC surveillance.[1]

- Placental and breast milk passage
  Emtricitabine has been shown to cross the placenta in mice and rabbits; the average fetal/maternal drug concentration was 0.4 in mice and 0.5 in rabbits.[2] Emtricitabine has been shown to have excellent placental transfer in pregnant women. In 18 women who received 200 mg emtricitabine once daily during pregnancy, mean cord blood concentration was 300 ± 268 ng/mL and mean ratios of cord blood/maternal emtricitabine concentrations were 1.17 ± 0.6 (n = 9).[3] When 35 women were administered 400 mg of emtricitabine in combination with tenofovir at delivery, median maternal and cord concentrations were 1.02 (0.034–2.04) and 0.74 (0.0005–1.46) mg/L, respectively.[4] Similarly, in a study of 26 women in P1026s who received emtricitabine during pregnancy, the mean cord:maternal blood ratio was 1.2 (90% CI, 1.0–1.5).[5] It is unknown if emtricitabine is excreted in human milk.

- Human studies in pregnancy
  Emtricitabine PKs have been evaluated in 18 HIV-infected pregnant women receiving antiretroviral therapy including emtricitabine (200 mg once daily) at 30 to 36 weeks' gestation and 6 to 12 weeks postpartum.[3] Emtricitabine exposure was modestly lower during the third trimester (8.6 µg*h/mL [5.2–15.9]) compared with the postpartum period (9.8 µg*h/mL [7.4–30.3]). Two-thirds (12 of 18) of pregnant women versus 100% (14 of 14) of postpartum women met the AUC target (10th percentile in non-pregnant adults). Trough emtricitabine levels were also lower during pregnancy (minimum plasma concentration [$C_{min}$] 52 ng/mL [14–180]) compared with the postpartum period (86 ng/mL [<10 to 306]). In another study of 35 women who received 400 mg of emtricitabine with tenofovir at delivery, median population AUC, maximum plasma concentration ($C_{max}$), and $C_{min}$ were 14.3 µg*h/mL, 1,680 ng/mL, and 76 ng/mL, respectively.[4] In the P1026s study, 26 women had emtricitabine PKs assessed during the third trimester (median 35 weeks) and 22 postpartum (mean 8 weeks postpartum).[5] Comparing PKs during pregnancy with postpartum, higher emtricitabine clearance (25.0 vs. 20.6 liters/hour during pregnancy vs. postpartum, respectively) and lower 24-hour post-dose levels (0.058 vs. 0.085 mg/liter) were seen but the 24-hour post-

dose levels were well above the inhibitory concentration 50% ($IC_{50}$) in all patients. Thus, these changes are not believed to be large enough to warrant dosage adjustment during pregnancy.

## References


1. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
2. Szczech GM, Wang LH, Walsh JP, Rousseau FS. Reproductive toxicology profile of emtricitabine in mice and rabbits. *Reprod Toxicol*. Jan-Feb 2003;17(1):95-108. Available at http://www.ncbi.nlm.nih.gov/pubmed/12507664.
3. Hirt D, Urien S, Rey E, et al. Population pharmacokinetics of emtricitabine in human immunodeficiency virus type 1-infected pregnant women and their neonates. *Antimicrob Agents Chemother*. Mar 2009;53(3):1067-1073. Available at http://www.ncbi.nlm.nih.gov/pubmed/19104016.
4. Best B, Stek A, Hu C, et al. High-dose lopinavir and standard-dose emtricitabine pharmacokinetics during pregnancy and postpartum. Paper presented at: 15th Conference on Retroviruses and Opportunistic Infections (CROI); February 3-8, 2008; Boston, MA. Abstract 629.
5. Stek AM, Best BM, Luo W, et al. Effect of pregnancy on emtricitabine pharmacokinetics. *HIV Med*. Apr 2012;13(4):226-235. Available at http://www.ncbi.nlm.nih.gov/pubmed/22129166.


***Lamivudine (Epivir, 3TC)*** is classified as FDA Pregnancy Category C.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Lamivudine has weak mutagenic activity in one *in vitro* assay but no evidence of *in vivo* genotoxicity in rats at 35 to 45 times human exposure. Long-term animal carcinogenicity screening studies at 10 and 58 times human exposure have been negative in mice and rats, respectively.
- Reproduction/fertility
  Lamivudine administered to rats at doses up to 4000 mg/kg/day, producing plasma levels 47 to 70 times those in humans, revealed no evidence of impaired fertility and no effect on the offsprings' survival, growth, and development up to the time of weaning.
- Teratogenicity/developmental toxicity studies
  There is no evidence of lamivudine-induced teratogenicity at 35 times human plasma levels in rats and rabbits. Early embryolethality was seen in rabbits at doses similar to human therapeutic exposure but not in rats at 35 times the human exposure level.

  In the Antiretroviral Pregnancy Registry, sufficient numbers of first-trimester exposures to lamivudine in humans have been monitored to detect at least a 1.5-fold increase in risk of overall birth defects and a 2-fold increase in the most commonly occurring birth defects, such as defects of the cardiovascular and genitourinary systems. No such increase in birth defects has been observed with lamivudine. Among cases of first-trimester lamivudine exposure reported to the Antiretroviral Pregnancy Registry, the prevalence of birth defects was 3.1% (127 of 4,088 births; 95% CI, 2.6%–3.7%) compared with a 2.7% total prevalence in the U.S. population, based on CDC surveillance.[1]
- Placental and breast milk passage
  Lamivudine readily crosses the placenta in humans, achieving comparable cord blood and maternal concentrations.[2] In a study of 123 mother/infant pairs, the placental transfer expressed as fetal-to-maternal AUC ratio was 0.86, and the lamivudine amniotic fluid accumulation, expressed as the amniotic fluid-to-fetal AUC ratio, was 2.9.[3] Other studies have also noted amniotic fluid accumulation of

lamivudine.[4] This is likely secondary to renal excretion of lamivudine by the fetus; lamivudine diffuses from maternal to fetal blood through the placenta and the fetal kidney removes lamivudine from fetal blood and concentrates it in urine, with fetal micturition causing a rise in the concentration of lamivudine in amniotic fluid.

Lamivudine is excreted into human breast milk. In a study in Kenya of 67 HIV-infected nursing mothers receiving a combination regimen of zidovudine, lamivudine, and nevirapine, the median breast milk lamivudine concentration was 1214 ng/mL and the median ratio of lamivudine concentration in breast milk to that in plasma was 2.56.[5] In infants who received lamivudine only via breast milk, median plasma lamivudine concentration was 23 ng/mL (half-maximal $IC_{50}$ of wild-type HIV against lamivudine = 0.6–21 ng/mL).

- Human studies in pregnancy

Two studies have evaluated lamivudine PKs in HIV-infected pregnant women, one evaluating drug levels in 57 mother/infant pairs on the day of delivery[4] and the other evaluating PKs in 20 women starting lamivudine/zidovudine at 38 weeks gestation.[2] These studies concluded that there was a lack of effect of pregnancy on lamivudine PKs after 38 weeks of pregnancy. In a larger study of 114 pregnant women, 123 women in labor, and 47 non-pregnant women receiving a lamivudine-containing regimen who had samples collected for therapeutic drug monitoring (given as 150 mg twice daily with zidovudine or 300 mg once daily with abacavir), data were retrospectively analyzed using a population PK approach.[3] Pregnant women had a 22% higher apparent clearance than non-pregnant and postpartum women, but this increase did not lead to subtherapeutic exposure; the level of lamivudine exposure in pregnant women, although lower than exposure in non-pregnant and parturient women, was relatively close to data reported previously for non-pregnant adults. Thus, no dose adjustment in pregnancy is necessary.

## References


1. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
2. Moodley J, Moodley D, Pillay K, et al. Pharmacokinetics and antiretroviral activity of lamivudine alone or when coadministered with zidovudine in human immunodeficiency virus type 1-infected pregnant women and their offspring. *J Infect Dis*. Nov 1998;178(5):1327-1333. Available at http://www.ncbi.nlm.nih.gov/pubmed/9780252.
3. Benaboud S, Treluyer JM, Urien S, et al. Pregnancy-related effects on lamivudine pharmacokinetics in a population study with 228 women. *Antimicrob Agents Chemother*. Feb 2012;56(2):776-782. Available at http://www.ncbi.nlm.nih.gov/pubmed/22106227.
4. Mandelbrot L, Peytavin G, Firtion G, Farinotti R. Maternal-fetal transfer and amniotic fluid accumulation of lamivudine in human immunodeficiency virus-infected pregnant women. *Am J Obstet Gynecol*. Jan 2001;184(2):153-158. Available at http://www.ncbi.nlm.nih.gov/pubmed/11174495.
5. Mirochnick M, Thomas T, Capparelli E, et al. Antiretroviral concentrations in breast-feeding infants of mothers receiving highly active antiretroviral therapy. *Antimicrob Agents Chemother*. Mar 2009;53(3):1170-1176. Available at http://www.ncbi.nlm.nih.gov/pubmed/19114673.


***Stavudine (Zerit, d4T)*** is classified as FDA Pregnancy Category C.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies

Stavudine is clastogenic in *in vitro* and *in vivo* assays but not mutagenic in *in vitro* assays. In 2-year carcinogenicity studies in mice and rats, stavudine was noncarcinogenic in doses producing exposures 39

(mice) and 168 (rats) times human exposure at the recommended therapeutic dose. At higher levels of exposure (250 [mice] and 732 [rats] times human exposure at therapeutic doses), benign and malignant liver tumors occurred in mice and rats and urinary bladder tumors occurred in male rats.

- Reproduction/fertility
  Stavudine has not been shown to have an effect on reproduction or fertility in rodents. A dose-related cytotoxic effect has been observed on preimplantation mouse embryos, with inhibition of blastocyst formation at a concentration of 100 μM and of postblastocyst development at 10 μM.[1]

- Teratogenicity/developmental toxicity studies
  No evidence of teratogenicity was noted in rats or rabbits with exposures (based on $C_{max}$) up to 399 and 183 times, respectively, of that seen at a clinical dosage of 1 mg/kg/day. In rat fetuses, the incidence of a common skeletal variation—unossified or incomplete ossification of sternebra—was increased with 399 times human exposure, although no effect was observed at 216 times human exposure. A slight post-implantation loss was noted at 216 times human exposure, with no effect noted at approximately 135 times human exposure. An increase in early rat neonatal mortality (birth to Day 4) occurred at 399 times human exposure, although survival of neonates was unaffected at approximately 135 times the human exposure. A study in rats showed that stavudine is transferred to the fetus through the placenta. The concentration in fetal tissue was approximately one-half the concentration in maternal plasma.

  In the Antiretroviral Pregnancy Registry, sufficient numbers of first-trimester exposures to stavudine in humans have been monitored to be able to detect at least a 2-fold increase in risk of overall birth defects. No such increase in birth defects has been observed with stavudine. Among cases of first-trimester stavudine exposure reported to the Antiretroviral Pregnancy Registry, the prevalence of birth defects was 2.5% (20 of 801 births; 95% CI, 1.5%–3.8%) compared with a total prevalence in the U.S. population of 2.7%, based on CDC surveillance.[2]

- Placental and breast milk passage
  Stavudine crosses the rat placenta *in vivo* and the human placenta *ex vivo*, resulting in a fetal/maternal concentration of approximately 0.50. In primates (pigtailed macaques), fetal/maternal plasma concentrations were approximately 0.80.[3] Stavudine is excreted into the breast milk of lactating rats.

- Human studies in pregnancy
  A Phase I/II safety and PK study has been conducted of combination stavudine and lamivudine in pregnant HIV-infected women and their infants (PACTG 332). Both drugs were well tolerated, with stavudine PKs similar to those in non-pregnant adults.[4] Data from primate studies also indicated that pregnancy did not affect the PKs of stavudine.[5]

  Lactic acidosis, in some cases fatal, has been described in pregnant women receiving the combination of didanosine and stavudine along with other ARV agents.[6-8] The FDA and Bristol-Myers Squibb have issued a warning to health care professionals that pregnant women may be at increased risk of fatal lactic acidosis when prescribed didanosine and stavudine in combination (see NRTI Drugs and Mitochondrial Toxicity in the perinatal guidelines). These drugs should be prescribed together for pregnant women only when the potential benefit clearly outweighs the potential risk. Clinicians should prescribe this ARV combination in pregnancy with caution and generally only when other nucleoside analog drug combinations have failed or have caused unacceptable toxicity or side effects.

## References


1. Toltzis P, Mourton T, Magnuson T. Comparative embryonic cytotoxicity of antiretroviral nucleosides. *J Infect Dis*. May 1994;169(5):1100-1102. Available at http://www.ncbi.nlm.nih.gov/pubmed/8169400.

2. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.

3. Odinecs A, Nosbisch C, Keller RD, Baughman WL, Unadkat JD. *In vivo* maternal-fetal pharmacokinetics of stavudine (2',3'-didehydro-3'-deoxythymidine) in pigtailed macaques (Macaca nemestrina). *Antimicrob Agents Chemother*. Jan 1996;40(1):196-202. Available at http://www.ncbi.nlm.nih.gov/pubmed/8787905.

4. Wade NA, Unadkat JD, Huang S, et al. Pharmacokinetics and safety of stavudine in HIV-infected pregnant women and their infants: Pediatric AIDS Clinical Trials Group protocol 332. *J Infect Dis*. Dec 15 2004;190(12):2167-2174. Available at http://www.ncbi.nlm.nih.gov/pubmed/15551216.

5. Odinecs A, Pereira C, Nosbisch C, Unadkat JD. Prenatal and postpartum pharmacokinetics of stavudine (2',3'-didehydro-3'-deoxythymidine) and didanosine (dideoxyinosine) in pigtailed macaques (Macaca nemestrina). *Antimicrob Agents Chemother*. Oct 1996;40(10):2423-2425. Available at http://www.ncbi.nlm.nih.gov/pubmed/8891157.

6. Bristol-Myers Squibb Company. Healthcare Provider Important Drug Warning Letter. January 5, 2001. 2001. Available at http://www.fda.gov/Safety/MedWatch/SafetyInformation/SafetyAlertsforHumanMedicalProducts/ucm173947.htm

7. Sarner L, Fakoya A. Acute onset lactic acidosis and pancreatitis in the third trimester of pregnancy in HIV-1 positive women taking antiretroviral medication. *Sex Transm Infect*. Feb 2002;78(1):58-59. Available at http://www.ncbi.nlm.nih.gov/pubmed/11872862.

8. Mandelbrot L, Kermarrec N, Marcollet A, et al. Case report: nucleoside analogue-induced lactic acidosis in the third trimester of pregnancy. *AIDS*. Jan 24 2003;17(2):272-273. Available at http://www.ncbi.nlm.nih.gov/pubmed/12545093.

***Tenofovir disoproxil fumarate (Viread, TDF)*** is classified as FDA Pregnancy Category B.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Tenofovir is mutagenic in one of two *in vitro* assays and has no evidence of clastogenic activity. Long-term oral carcinogenicity studies of tenofovir disoproxil fumarate in mice and rats were carried out at 16 times (mice) and 5 times (rats) human exposure. In female mice, liver adenomas were increased at exposures 16 times that observed in humans at therapeutic doses. In rats, the study was negative for carcinogenic findings at exposures up to 5 times that observed in humans at the therapeutic dose.

- Reproduction/fertility
  Reproduction studies have been performed in rats and rabbits at doses up to 14 and 19 times the human dose based on body surface area comparisons and revealed no evidence of impaired fertility or harm to the fetus associated with tenofovir. There were also no effects on fertility, mating performance, or early embryonic development when tenofovir disoproxil fumarate was administered to male rats (600 mg/kg/day; equivalent to 10 times the human dose based on body surface area) for 28 days before mating and to female rats for 15 days before mating through Day 7 of gestation. There was, however, an alteration of the estrous cycle in female rats administered 600 mg/kg/day.

- Teratogenicity/developmental toxicity
  Chronic exposure of fetal monkeys to tenofovir at a high dose of 30 mg/kg (exposure equivalent to 25 times the AUC achieved with therapeutic dosing in humans) from Days 20 to 150 of gestation did not result in gross structural abnormalities.[1] However, significantly lower fetal circulating insulin-like growth factor (IGF)-1 (a primary regulator of linear growth) and higher IGF binding protein-3 levels were shown and were associated with overall body weights approximately 13% lower than untreated controls. A slight reduction in fetal bone porosity was also observed. Effects on these parameters were observed within 2 months of maternal treatment. Significant changes in maternal monkey bone biomarkers were noted but were primarily limited to the treatment period and were reversible.

Continued administration of tenofovir at 30 mg/kg/day to infant monkeys resulted in significant growth restriction and severe bone toxicity in 2 of 8 (25%) infants and effects on bone biomarkers and defective bone mineralization in all animals. Chronic administration of tenofovir to immature animals of multiple species has resulted in reversible bone abnormalities; these effects were dose, exposure, age, and species specific. Abnormalities ranged from minimal decrease in bone mineral density and content (with oral dosing in rats and dogs that achieved drug exposures 6 to 10 times that achieved with therapeutic dosing in humans) to severe, pathologic osteomalacia (with subcutaneous [SQ] dosing given to monkeys). Juvenile monkeys given chronic SQ tenofovir at 30 mg/kg/day (exposure equivalent to 25 times the AUC achieved with therapeutic dosing in humans) developed osteomalacia, bone fractures, and marked hypophosphatemia. However, no clinical or radiologic bone toxicity was seen when juvenile monkeys received SQ dosing of 10 mg/kg/day (exposure equivalent to 8 times the AUC achieved with therapeutic dosing in humans). Evidence of nephrotoxicity was observed in newborn and juvenile monkeys given tenofovir in doses resulting in exposures 12 to 50 times higher than the human dose, based on body surface area comparisons.

In the Antiretroviral Pregnancy Registry, sufficient numbers of first-trimester exposures to tenofovir in humans have been monitored to be able to detect at least a 2-fold increase in risk of overall birth defects. No such increase in birth defects has been observed with tenofovir. Among cases of first-trimester tenofovir exposure reported to the Antiretroviral Pregnancy Registry, the prevalence of birth defects was 2.3% (31 of 1,370 births; 95% CI, 1.5%–3.2%) compared with a 2.7% total prevalence in the U.S. population, based on CDC surveillance.[2]

- Placental and breast milk passage

  Studies in rats have demonstrated that tenofovir is secreted in milk. Intravenous administration of tenofovir to pregnant cynomolgus monkeys resulted in a fetal/maternal concentration of 17%, demonstrating that tenofovir does cross the placenta.[3] In studies of pregnant women on chronic dosing, the cord-to-maternal blood ratio ranged from 0.60 to 1.03, indicating high placental transfer.[4-7] In a study of 31 pregnant women receiving single-dose tenofovir (with and without emtricitabine) in labor, the drugs were well-tolerated and the median tenofovir cord-to-maternal blood ratio at delivery was 0.73 (range, 0.26 to 1.95).[8] In a study evaluating intracellular tenofovir levels in newborns, intracellular tenofovir concentrations were detected in the peripheral blood mononuclear cells from cord blood in all infants after a maternal single dose of 600 mg tenofovir with 400 mg emtricitabine, but intracellular tenofovir diphosphate was detectable in only 2 (5.5%) of 36.[9] Neonatal dosing of tenofovir resulted in tenofovir and tenofovir diphosphate levels similar to those in adults.[9]

  Among women receiving a single 600-mg dose during labor, tenofovir was detectable in only 4 of 25 (16%) breast milk samples during the first week after delivery, with a median concentration of 13 (range 6–18) ng/mL.[8] In another study, 16 breast milk samples were obtained from 5 women who received 600 mg of tenofovir at the start of labor followed by 300 mg daily for 7 days. Tenofovir levels in breast milk ranged from 5.8 to 16.3 ng/mL, and nursing infants received an estimated 0.03% of the proposed oral dose of tenofovir for neonates.[10]

- Human studies in pregnancy

  A retrospective population PK study was performed on samples collected for therapeutic drug monitoring from 46 pregnant women and 156 non-pregnant women receiving combination regimens including tenofovir.[11] Pregnant women had a 39% higher apparent clearance compared with non-pregnant women, which decreased slightly but significantly with increasing age. In study P1026s, tenofovir PKs were evaluated in 19 pregnant women receiving tenofovir-based combination therapy at 30 to 36 weeks' gestation and 6 to 12 weeks postpartum.[4] The percentage of women with tenofovir AUC exceeding the target of 2 μg*hour/mL (the 10th percentile in non-pregnant adults) was lower in the third trimester (74%, 14 of 19 women) than postpartum (86%, 12 of 14 women) ($P$ = .02); however, trough levels were

similar in the two groups. At the present time, standard dosing during pregnancy continues to be recommended.

A recent case series found tenofovir to be well tolerated among 76 pregnant women, with only 2 stopping therapy, 1 for rash and the other for nausea. All 78 infants were healthy with no signs of toxicity, and all were HIV uninfected.[12] A follow-up study of 20 of the tenofovir-exposed infants and 20 controls found no differences between the groups in renal function, including cystatin C levels, through age 2 years.[13] A retrospective review of 16 pregnancy outcomes in 15 heavily ARV experienced women demonstrated that tenofovir was well tolerated by the women and associated with normal growth and development in the infants.[14] In a cross-sectional study of 68 HIV-exposed uninfected infants who had *in utero* exposure to combination regimens with (N = 33) or without (N = 35) tenofovir, the incidence of low birth weight and length measurements (<10$^{th}$ percentile) was comparable in the two groups and evaluation of quantitative bone ultrasound and parameters of bone metabolism gave similar measures between groups.[15] The Pediatric HIV/AIDS Cohort Study from the United States reported on the association of tenofovir use during pregnancy with early growth parameters in 449 HIV-exposed but -uninfected infants.[16] Of 2,029 infants, 449 (21%) had *in utero* exposure to tenofovir. There was no difference at birth between those exposed to combination drug regimens with or without tenofovir for low birth weight, small-for-gestational-age, and newborn length-for-age and head circumference-for-age z-scores (LAZ and HCAZ, respectively). At age 1 year, infants exposed to combination regimens with tenofovir had a slight but significantly lower adjusted mean LAZ and HCAZ than those without tenofovir exposure (LAZ: -0.17 vs. -0.03, $P = .04$; HCAZ: 0.17 vs. 0.42, $P = .02$), but not lower weight-for-age z-score. However, there were no significant differences between those with and without tenofovir exposure at age 1 year when defining low LAZ or HCAZ as <-1.5 z-score. Thus, these slightly lower mean LAZ and HCAZ scores are of uncertain significance.

## References


1. Tarantal AF, Castillo A, Ekert JE, Bischofberger N, Martin RB. Fetal and maternal outcome after administration of tenofovir to gravid rhesus monkeys (Macaca mulatta). *J Acquir Immune Defic Syndr*. Mar 1 2002;29(3):207-220. Available at http://www.ncbi.nlm.nih.gov/pubmed/11873070.
2. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
3. Tarantal AF, Marthas ML, Shaw JP, Cundy K, Bischofberger N. Administration of 9-[2-(R)-(phosphonomethoxy)propyl]adenine (PMPA) to gravid and infant rhesus macaques (Macaca mulatta): safety and efficacy studies. *J Acquir Immune Defic Syndr Hum Retrovirol*. Apr 1 1999;20(4):323-333. Available at http://www.ncbi.nlm.nih.gov/pubmed/10096575.
4. Burchett S, Best B, Mirochnick M, et al.Tenofovir pharmacokinetics during pregnancy, at delivery, and postpartum. Paper presented at: 14th Conference on Retroviruses and Opportunistic Infections (CROI); February 25-28, 2007; Los Angeles, CA. Abstract 738b.
5. Bonora S, de Requena DG, Chiesa E, et al.Transplacental passage of tenofovir and other ARVs at delivery. Paper presented at: 14th Conference on Retoviruses and Opportunistic Infections (CROI); February 25-28, 2007; Los Angeles, CA. Abstract 738a.
6. Hirt D, Urien S, Rey E, et al. Population pharmacokinetics of emtricitabine in human immunodeficiency virus type 1-infected pregnant women and their neonates. *Antimicrob Agents Chemother*. Mar 2009;53(3):1067-1073. Available at http://www.ncbi.nlm.nih.gov/pubmed/19104016.
7. Colbers A, Taylor G, et al.A comparison of the pharmacokinetics of tenofovir during pregnancy and post-partum. Paper presented at: 13th International Workshop on Clinical Pharmacology of HIV Therapy; April 16-18, 2012; Barcelona,

Spain. Abstract P34.

8. Flynn PM, Mirochnick M, Shapiro DE, et al. Pharmokinetics and Safety of Single-Dose Tenofovir Disoproxil Fumarate and Emtricitabine in HIV-1-Infected Pregnant Women and Their Infants. *Antimicrob Agents Chemother*. Dec 2011;55(12):5914-22. Available at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3232794/?tool=pmcentrez.
9. Hirt D, Ekouevi DK, Pruvost A, et al. Plasma and intracellular tenofovir pharmacokinetics in the neonate (ANRS 12109 trial, step 2). *Antimicrob Agents Chemother*. Jun 2011;55(6):2961-2967. Available at http://www.ncbi.nlm.nih.gov/pubmed/21464249.
10. Benaboud S, Pruvost A, Coffie PA, et al. Concentrations of tenofovir and emtricitabine in breast milk of HIV-1-infected women in Abidjan, Cote d'Ivoire, in the ANRS 12109 TEmAA Study, Step 2. *Antimicrob Agents Chemother*. Mar 2011;55(3):1315-1317. Available at http://www.ncbi.nlm.nih.gov/pubmed/21173182.
11. Benaboud S, Hirt D, Launay O, et al. Pregnancy-related effects on tenofovir pharmacokinetics: a population study with 186 women. *Antimicrob Agents Chemother*. Feb 2012;56(2):857-862. Available at http://www.ncbi.nlm.nih.gov/pubmed/22123690.
12. Haberl A, Linde R, Reittner A, et al. Safety and efficacy of tenofovir in pregnant women. Paper presented at: 15th Conference on Retroviruses and Opportunistic Infections (CROI); February 3-6, 2008; Boston, MA. Abstract 627a.
13. Linde R, Konigs C, Rusicke E, Haberl A, Reitter A, Dreuz W. Tenofovir therapy during pregnancy does not affect renal function in HIV-exposed children. Paper presented at: 17th Conference on Retoviruses and Opportunistic Infections (CROI); February 27-March 2, 2010; San Francisco, CA. Abstract 925.
14. Nurutdinova D, Onen NF, Hayes E, Mondy K, Overton ET. Adverse effects of tenofovir use in HIV-infected pregnant women and their infants. *Ann Pharmacother.* Nov 2008;42(11):1581-1585. Available at http://www.ncbi.nlm.nih.gov/pubmed/18957630.
15. Vigano A, Mora S, Giacomet V, et al. *In utero* exposure to tenofovir disoproxil fumarate does not impair growth and bone health in HIV-uninfected children born to HIV-infected mothers. *Antivir Ther*. 2011;16(8):1259-1266. Available at http://www.ncbi.nlm.nih.gov/pubmed/22155907.
16. Siberry GK, Williams PL, Mendez H, et al. Safety of tenofovir use during pregnancy: early growth outcomes in HIV-exposed uninfected infants. *AIDS*. Jun 1 2012;26(9):1151-1159. Available at http://www.ncbi.nlm.nih.gov/pubmed/22382151.

***Zalcitabine (HIVID, ddC)*** is no longer available in the United States.

**(Last updated September 14, 2011; last reviewed July 31, 2012)**

***Zidovudine (Retrovir, AZT, ZDV)*** is classified as FDA Pregnancy Category C.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies

  Zidovudine was shown to be mutagenic in two *in vitro* assays and clastogenic in one *in vitro* and two *in vivo* assays, but not cytogenic in a single-dose *in vivo* rat study. Long-term carcinogenicity studies have been performed with zidovudine in mice and rats.[1] In mice, seven late-appearing (>19 months) vaginal neoplasms (five nonmetastasizing squamous cell carcinomas, one squamous cell papilloma, and one squamous polyp) occurred in animals given the highest dose. One late-appearing squamous cell papilloma occurred in the vagina of an animal given an intermediate dose. No vaginal tumors were found at the lowest dose. In rats, two late-appearing (>20 months), nonmetastasizing vaginal squamous cell carcinomas occurred in animals given the highest dose. No vaginal tumors occurred at the low or middle dose in rats. No other drug-related tumors were observed in either sex in either species. At doses that produced tumors in mice and rats, the estimated drug exposure (as measured by AUC) was approximately 3 times (mouse)

and 24 times (rat) the estimated human exposure at the recommended therapeutic dose of 100 mg every 4 hours. How predictive the results of rodent carcinogenicity studies may be for humans is unknown.

Two transplacental carcinogenicity studies were conducted in mice.[2, 3] In one study, zidovudine was administered at doses of 20 mg/kg/day or 40 mg/kg/day from gestation Day 10 through parturition and lactation, with postnatal dosing continuing in offspring for 24 months.[3] The drug doses administered in this study produced zidovudine exposures approximately 3 times the estimated human exposure at recommended doses. After 24 months, an increase in incidence of vaginal tumors was noted with no increase in tumors in the liver or lung or any other organ in either gender. These findings are consistent with results of the standard oral carcinogenicity study in mice, as described earlier. In a second study, zidovudine was administered at maximum tolerated doses of 12.5 mg/day or 25 mg/day (~1000 mg/kg non-pregnant body weight or ~450 mg/kg of term body weight) to pregnant mice from Days 12 to 18 of gestation.[2] There was an increase in the number of tumors in the lung, liver, and female reproductive tracts in the offspring of mice receiving the higher dose level of zidovudine.

- Reproduction/fertility
  When administered to male and female rats at doses up to 7 times the usual adult dose based on body surface area, zidovudine had no effect on fertility, as judged by rates of conception.

  Zidovudine has been shown to have no effect on reproduction or fertility in rodents. A dose-related cytotoxic effect on preimplantation mouse embryos can occur, with inhibition of blastocyst and postblastocyst development at zidovudine concentrations similar to levels achieved with human therapeutic doses.[4]

- Teratogenicity/developmental toxicity
  Oral teratology studies in the rat and in the rabbit at doses up to 500 mg/kg/day revealed no evidence of teratogenicity with zidovudine. Zidovudine treatment resulted in embryo/fetal toxicity, as evidenced by an increase in the incidence of fetal resorptions in rats given 150 or 450 mg/kg/day and rabbits given 500 mg/kg/day. The doses used in the teratology studies resulted in peak zidovudine plasma concentrations (after one-half of the daily dose) in rats 66 to 226 times and in rabbits 12 to 87 times mean steady-state peak human plasma concentrations (after one-sixth of the daily dose) achieved with the recommended daily dose (100 mg every 4 hours). In an *in vitro* experiment with fertilized mouse oocytes, zidovudine exposure resulted in a dose-dependent reduction in blastocyst formation. In an additional teratology study in rats, a dose of 3000 mg/kg/day (very near the oral median lethal dose in rats of 3683 mg/kg) caused marked maternal toxicity and an increase in incidence of fetal malformations. This dose resulted in peak zidovudine plasma concentrations 350 times peak human plasma concentrations. (Estimated AUC in rats at this dose level was 300 times the daily AUC in humans given 600 mg/day.) No evidence of teratogenicity was seen in this experiment at doses of 600 mg/kg/day or less.

  Increased fetal resorption occurred in pregnant rats and rabbits treated with zidovudine doses that produced drug plasma concentrations 66 to 226 times (rats) and 12 to 87 times (rabbits) the mean steady-state peak human plasma concentration following a single 100-mg dose of zidovudine. No other developmental anomalies were reported. In another developmental toxicity study, pregnant rats received zidovudine up to near-lethal doses that produced peak plasma concentrations 350 times peak human plasma concentrations (300 times the daily AUC in humans given 600 mg/day zidovudine). This dose was associated with marked maternal toxicity and an increased incidence of fetal malformations. However, there were no signs of teratogenicity at doses up to one-fifth the lethal dose.

  In humans, in the placebo-controlled perinatal trial PACTG 076, the incidence of minor and major congenital abnormalities was similar between zidovudine and placebo groups and no specific patterns of defects were seen.[5, 6] A report from the Women and Infants Transmission Study, a cohort study enrolling

women during pregnancy, described an association between first-trimester exposure to zidovudine and a 10-fold increased risk of hypospadias.[7] However, in the Antiretroviral Pregnancy Registry, sufficient numbers of first-trimester exposures to zidovudine have been monitored to be able to detect at least a 1.5-fold increase in risk of overall birth defects and a 2-fold increase in defects in the more common classes, defects of the cardiovascular and genitourinary systems. No such increase in birth defects has been observed with zidovudine. With first-trimester zidovudine exposure, the prevalence of birth defects was 3.3% (124 of 3,789 births; 95% CI, 2.7%–3.9%) compared with a total prevalence in the U.S. population of 2.7%, based on CDC surveillance.[8]

- Placental and breast milk passage
  Zidovudine rapidly crosses the human placenta, achieving cord-to-maternal blood ratios of about 0.80. Zidovudine is excreted into human breast milk. In one study in Kenya in 67 mothers receiving a combination regimen of zidovudine, lamivudine, and nevirapine, zidovudine concentration in the breast milk of mothers averaged 9 ng/mL and the ratio of breast milk to maternal plasma zidovudine concentration averaged 44%.[9] No zidovudine was detectable in the plasma of the nursing infants, who received zidovudine only via breast milk.

- Human studies in pregnancy
  Zidovudine is well tolerated in pregnancy at recommended adult doses and in the full-term neonate at 2 mg/kg body weight orally every 6 hours.[5, 10] Long-term data on the safety of *in utero* drug exposure in humans are not available for any ARV drug; however, short-term data on the safety of zidovudine are reassuring. In PACTG 076, no difference in disease progression was seen between women who received zidovudine and those who received placebo, based on follow-up through 4 years postpartum.[11] Additionally, no differences in immunologic, neurologic, or growth parameters were seen between infants with *in utero* zidovudine exposure and those who received placebo, based on nearly 6 years of follow-up.[6, 12]

## References


1. Ayers KM, Clive D, Tucker WE, Jr., Hajian G, de Miranda P. Nonclinical toxicology studies with zidovudine: genetic toxicity tests and carcinogenicity bioassays in mice and rats. *Fundam Appl Toxicol*. Aug 1996;32(2):148-158. Available at http://www.ncbi.nlm.nih.gov/pubmed/8921318.
2. Olivero OA, Anderson LM, Diwan BA, et al. Transplacental effects of 3'-azido-2',3'-dideoxythymidine (AZT): tumorigenicity in mice and genotoxicity in mice and monkeys. *J Natl Cancer Inst*. 1997;89(21):1602-1608. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=PubMed&list_uids=9362158&dopt=Abstract.
3. Ayers KM, Torrey CE, Reynolds DJ. A transplacental carcinogenicity bioassay in CD-1 mice with zidovudine. *Fundam Appl Toxicol*. Aug 1997;38(2):195-198. Available at http://www.ncbi.nlm.nih.gov/pubmed/9299194.
4. Toltzis P, Marx CM, Kleinman N, Levine EM, Schmidt EV. Zidovudine-associated embryonic toxicity in mice. *J Infect Dis*. Jun 1991;163(6):1212-1218. Available at http://www.ncbi.nlm.nih.gov/pubmed/2037787.
5. Connor EM, Sperling RS, Gelber R, et al. Reduction of maternal-infant transmission of human immunodeficiency virus type 1 with zidovudine treatment. Pediatric AIDS Clinical Trials Group Protocol 076 Study Group. *N Engl J Med*. Nov 3 1994;331(18):1173-1180. Available at http://www.ncbi.nlm.nih.gov/pubmed/7935654.
6. Sperling RS, Shapiro DE, McSherry GD, et al. Safety of the maternal-infant zidovudine regimen utilized in the Pediatric AIDS Clinical Trial Group 076 Study. *AIDS*. Oct 1 1998;12(14):1805-1813. Available at http://www.ncbi.nlm.nih.gov/pubmed/9792381.
7. Watts DH, Li D, Handelsman E, et al. Assessment of birth defects according to maternal therapy among infants in the Women and Infants Transmission Study. *J Acquir Immune Defic Syndr*. Mar 1 2007;44(3):299-305. Available at http://www.ncbi.nlm.nih.gov/pubmed/17159659.

8. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.

9. Mirochnick M, Thomas T, Capparelli E, et al. Antiretroviral concentrations in breast-feeding infants of mothers receiving highly active antiretroviral therapy. *Antimicrob Agents Chemother*. Mar 2009;53(3):1170-1176. Available at http://www.ncbi.nlm.nih.gov/pubmed/19114673.

10. O'Sullivan MJ, Boyer PJ, Scott GB, et al. The pharmacokinetics and safety of zidovudine in the third trimester of pregnancy for women infected with human immunodeficiency virus and their infants: phase I acquired immunodeficiency syndrome clinical trials group study (protocol 082). Zidovudine Collaborative Working Group. *Am J Obstet Gynecol*. 1993;168(5):1510-1516. Available at http://www.ncbi.nlm.nih.gov/entrez/query.fcgi?cmd=Retrieve&db=pubmed&dopt=Abstract&list_uids=8098905.

11. Bardeguez AD, Shapiro DE, Mofenson LM, et al. Effect of cessation of zidovudine prophylaxis to reduce vertical transmission on maternal HIV disease progression and survival. *J Acquir Immune Defic Syndr*. Feb 1 2003;32(2):170-181. Available at http://www.ncbi.nlm.nih.gov/pubmed/12571527.

12. Culnane M, Fowler M, Lee SS, et al. Lack of long-term effects of *in utero* exposure to zidovudine among uninfected children born to HIV-infected women. Pediatric AIDS Clinical Trials Group Protocol 219/076 Teams. *JAMA*. Jan 13 1999;281(2):151-157. Available at http://www.ncbi.nlm.nih.gov/pubmed/9917118.

## Non-Nucleoside Reverse Transcriptase Inhibitors

| Glossary of Terms for Supplement |
|---|
| **Carcinogenic** = producing or tending to produce cancer<br>• Some agents, such as certain chemicals or forms of radiation, are both mutagenic and clastogenic.<br>• Genetic mutations and/or chromosomal damage can contribute to cancer formation. |
| **Clastogenic** = causing disruption of or breakages in chromosomes |
| **Genotoxic** = damaging to genetic material such as DNA and chromosomes |
| **Mutagenic** = inducing or capable of inducing genetic mutation |
| **Teratogenic** = interfering with fetal development and resulting in birth defects |

Five non-nucleoside analogue reverse transcriptase inhibitors (NNRTIs) currently are approved (delavirdine is no longer available in the United States). Nevirapine and efavirenz have been studied in human pregnancy. No adequate and well-controlled studies of etravirine or rilpivirine use in pregnant women have been conducted.

For information about potential interactions between NNRTIs and methergine, see Postpartum Hemorrhage, Antiretroviral Drugs, and Methergine Use in the perinatal guidelines. For more information regarding nevirapine hepatic/rash toxicity, see Nevirapine and Hepatic/Rash Toxicity in the perinatal guidelines.

***Delavirdine (Rescriptor, DLV)*** is no longer available in the United States.
**(Last updated September 14, 2011; last reviewed July 31, 2011)**

***Efavirenz (Sustiva, EFV)*** is classified as Food and Drug Administration (FDA) Pregnancy Category D.
**(Last updated July 31, 2011; last reviewed July 31, 2011)**

- Animal carcinogenicity studies
  Efavirenz was neither mutagenic nor clastogenic in a series of *in vitro* and animal *in vivo* screening tests. Long-term animal carcinogenicity studies with efavirenz have been completed in mice and rats. At systemic drug exposures approximately 1.7-fold higher than in humans receiving standard therapeutic doses, no increase in tumor incidence above background was observed in male mice, but in female mice, an increase above background was seen in hepatocellular adenomas and carcinomas and pulmonary alveolar/bronchiolar adenomas. No increase in tumor incidence above background was observed in male and female rats with systemic drug exposures lower than that in humans receiving therapeutic doses.

- Reproduction/fertility animal studies
  No effect of efavirenz on reproduction or fertility in rodents has been seen.

- Teratogenicity/developmental toxicity
  An increase in fetal resorption was observed in rats at efavirenz doses that produced peak plasma concentrations and area under the curve (AUC) values in female rats equivalent to or lower than those achieved in humans at the recommended human dose (600 mg once daily). Efavirenz produced no reproductive toxicities when given to pregnant rabbits at doses that produced peak plasma concentrations similar to and AUC values approximately half of those achieved in humans administered efavirenz (600

mg once daily). Central nervous system (CNS) malformations and cleft palate were observed in 3 of 20 infants born to pregnant cynomolgus monkeys receiving efavirenz from gestational Days 20 to 150 at a dose of 30 mg/kg twice daily (resulting in plasma concentrations comparable to systemic human therapeutic exposure).[1] The malformations included anencephaly and unilateral anophthalmia in one fetus, microphthalmia in another fetus, and cleft palate in a third fetus.

- Placental and breast milk passage
  Efavirenz crosses the placenta in rats, rabbits, and primates, producing cord blood concentrations similar to concentrations in maternal plasma. In a study of 13 women in Rwanda, efavirenz was given during the last trimester of pregnancy and for 6 months after delivery.[2] Efavirenz concentrations were measured in maternal plasma, breast milk, and infant plasma. Efavirenz passed into breast milk with a ratio of 0.54 (mean breast milk to mean maternal plasma concentration) and 4.08 (mean skim milk to mean newborn plasma concentration). Mean infant plasma efavirenz concentrations were 13.1% of maternal plasma levels. No data currently are available about efavirenz in neonates.

- Human studies in pregnancy
  In pregnancies with prospectively reported exposure to efavirenz-based regimens in the Antiretroviral Pregnancy Registry through January 2012, birth defects were observed in 18 of 679 live births with first-trimester exposure (2.7%, 95% confidence interval [CI], 1.6%–4.2%).[3] Although these data provide sufficient numbers of first-trimester exposures to rule out a 2-fold or greater increase in the risk of overall birth defects, the low incidence of neural tube defects in the general population means that a larger number of exposures are still needed to be able to definitively rule out an increased risk of this specific defect. Prospective reports to the Antiretroviral Pregnancy Registry of defects after first-trimester efavirenz exposure have documented 1 neural tube defect case (sacral aplasia, myelomeningocele, and hydrocephalus with fetal alcohol syndrome) and 1 case of bilateral facial clefts, anophthalmia, and amniotic band.[3] Among retrospective cases, there are 6 reports of CNS defects, including 3 cases of meningomyelocele in infants born to mothers receiving efavirenz during the first trimester.[4] Retrospective reports can be biased toward reporting of more unusual and severe cases and are less likely to be representative of the general population experience.

  In an updated meta-analysis of 19 studies (including the Antiretroviral Pregnancy Registry data) reporting on birth outcomes among women exposed to efavirenz during the first trimester, there were 39 infants with birth defects among live births in 1,437 women receiving first-trimester efavirenz (rate of overall birth defects, 2.0%, 95% CI, 0.8–3.2%).[5] The rate of overall birth defects was similar among women exposed to efavirenz-containing regimens (1,290 live births) and non-efavirenz containing regimens (8,122 births) during the first trimester (pooled relative risk [RR] 0.85, 95% CI, 0.61–1.20). Across all births (1,437 live births with first-trimester efavirenz exposure), 1 neural tube defect (myelomeningocele) was observed, giving a point prevalence of 0.07% (95% CI, 0.002–0.39), within the range reported in the general population. However, the number of reported first-trimester efavirenz exposures still remains insufficient to rule out a significant increase in low-incidence birth defects (incidence of neural tube defects in the general U.S. population is 0.02%–0.2%).

  In contrast to the meta-analysis, the Pediatric AIDS Clinical Trials Protocols (PACTG) 219 and 219C studies reported a higher defect rate among infants with first-trimester exposure to efavirenz compared with those without such exposure (adjusted odds ratio 4.31, 95% CI, 1.56–11.86). However, only 32 infants had efavirenz exposure. The PACTG protocol P1025 is a companion study of PACTG 219 with considerable overlap of the cases enrolled. Whereas the P1025 study reported a significant increased risk of congenital anomalies in infants born between 2002 and 2007 with first-trimester exposure to efavirenz, there is overlap in the defect cases between the two studies and only 42 infants are included in this analysis. Thus, additional data are needed on first-trimester efavirenz exposures to more conclusively

determine if risk of neural tube defects is elevated.

Efavirenz is classified as FDA Pregnancy Category D, which means that there is positive evidence of human fetal risk based on studies in humans, but potential benefits may warrant use of the drug in pregnant women despite potential risks. Although the limited data on first-trimester efavirenz exposure cannot rule out a 2- or 3-fold increased incidence of a rare outcome, such as neural tube defects, the available data from the meta-analysis on >1,400 births suggest that there is not a large increase (such as a 10-fold increase) in the risk of neural tube defects with first-trimester exposure. Because of the potential for teratogenicity, pregnancy should be avoided in women receiving efavirenz, and treatment with efavirenz should be avoided during the first trimester (the primary period of fetal organogenesis) whenever possible. Women of childbearing potential should undergo pregnancy testing before initiation of efavirenz and should be counseled about the potential risk to the fetus and desirability of avoiding pregnancy. Alternate antiretroviral (ARV) regimens that do not include efavirenz should be strongly considered in women who are planning to become pregnant or who are sexually active and not using effective contraception if such alternative regimens are acceptable to provider and patient and will not compromise the woman's health. However, given that the risk of neural tube defects is restricted to the first 5 to 6 weeks of pregnancy (the neural tube closes at 36–39 days after last menstrual period), pregnancy is rarely recognized before 4 to 6 weeks of pregnancy, and ARV drug changes in pregnancy may be associated with loss of viral control and thus increase risk of transmission to the infant,[6] efavirenz can be continued in pregnant women receiving efavirenz-based antiretroviral therapy (ART) who present for antenatal care in the first trimester, provided that the regimen produces virologic suppression. In such situations, additional fetal monitoring (such as second-trimester ultrasound) should be considered to evaluate fetal anatomy.

Higher rates of failure for hormonal contraceptives containing estrogen and progesterone may be associated with ARV drugs such as efavirenz. Alternate ARV regimens that do not include efavirenz should be strongly considered in women who are planning to become pregnant or who are sexually active and not using effective contraception if such alternative regimens are acceptable to provider and patient and will not compromise the woman's health. Barrier contraception should always be used in combination with other methods of contraception such as hormonal contraceptives and intrauterine devices. A study evaluating the interaction between efavirenz and depot medroxyprogesetrone (DMPA) in 17 women found no change in the pharmacokinetic (PK) profile of either efavirenz or DMPA with concomitant use.[7] DMPA levels remained above the level needed for inhibition of ovulation throughout the dosing interval.

Limited PK data exist for efavirenz in pregnancy. In a study of 25 pregnant women receiving efavirenz during the third trimester as part of clinical care, efavirenz clearance was increased and clearance after 24 hours was decreased compared with postpartum. These differences are not of sufficient magnitude to warrant dose adjustment during pregnancy.[8]

## References


1. Nightingale SL. From the Food and Drug Administration. *JAMA*. Nov 4 1998;280(17):1472.Available at http://www.ncbi.nlm.nih.gov/pubmed/9809716.
2. Schneider S, Peltier A, Gras A, et al. Efavirenz in human breast milk, mothers', and newborns' plasma. *J Acquir Immune Defic Syndr*. Aug 1 2008;48(4):450-454. Available at http://www.ncbi.nlm.nih.gov/pubmed/18614925.
3. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center. 2012. Available at http://www.APRegistry.com.
4. Bristol-Myers Squibb Company. Efavirenz drug label. Revised June 2012. Available at

http://www.accessdata.fda.gov/drugsatfda_docs/label/2012/020972s041,021360s029lbl.pdf. Accessed on June 25, 2012.

5. Ford N, Calmy A, Mofenson L. Safety of efavirenz in the first trimester of pregnancy: an updated systematic review and meta-analysis. *AIDS*. Nov 28 2011;25(18):2301-2304. Available at http://www.ncbi.nlm.nih.gov/pubmed/21918421.
6. Floridia M, Ravizza M, Pinnetti C, et al. Treatment change in pregnancy is a significant risk factor for detectable HIV-1 RNA in plasma at end of pregnancy. *HIV Clin Trials*. Nov-Dec 2010;11(6):303-311. Available at http://www.ncbi.nlm.nih.gov/pubmed/21239358.
7. Cohn SE, Park JG, Watts DH, et al. Depo-medroxyprogesterone in women on antiretroviral therapy: effective contraception and lack of clinically significant interactions. *Clin Pharmacol Ther*. Feb 2007;81(2):222-227. Available at http://www.ncbi.nlm.nih.gov/pubmed/17192768.
8. Cressey TR, Stek A, Capparelli E, et al. Efavirenz pharmacokinetics during the third trimester of pregnancy and postpartum. *J Acquir Immune Defic Syndr*. Mar 1 2012;59(3):245-252. Available at http://www.ncbi.nlm.nih.gov/pubmed/22083071.

***Etravirine (Intelence, ETV)*** is classified as FDA Pregnancy Category B.

**(Last updated July 31, 2011; last reviewed July 31, 2011)**

- Animal carcinogenicity studies
  Etravirine was neither mutagenic nor clastogenic in a series of *in vitro* and animal *in vivo* screening tests. Etravirine was evaluated for carcinogenic potential by oral gavage administration to mice and rats for up to approximately 104 weeks. Daily doses of 50, 200, and 400 mg/kg were administered to mice and doses of 70, 200, and 600 mg/kg were administered to rats in the initial period of approximately 41 to 52 weeks. The high and middle doses were subsequently adjusted because of tolerability and reduced by 50% in mice and by 50% to 66% in rats to allow for completion of the studies. In the mouse study, statistically significant increases in the incidences of hepatocellular carcinoma and incidences of hepatocellular adenomas or carcinomas combined were observed in treated females. In the rat study, no statistically significant increases in tumor findings were observed in either sex. The relevance to humans of these liver tumor findings in mice is unknown. Because of tolerability of the formulation in these rodent studies, maximum systemic drug exposures achieved at the doses tested were lower than those in humans at the clinical dose (400 mg/day), with animal versus human AUC ratios being 0.6-fold (mice) and 0.2 to 0.7-fold (rats).

- Reproduction/fertility
  No effect on fertility and early embryonic development was observed when etravirine was tested in rats at maternal doses up to 500 mg/kg/day, resulting in systemic drug exposure equivalent to the recommended human dose (400 mg/day).

- Teratogenicity/developmental toxicity
  Animal reproduction studies in rats and rabbits at systemic exposures equivalent to those at the recommended human dose of 400 mg/day revealed no evidence of fetal toxicity or altered development. Developmental toxicity studies were performed in rabbits (at oral doses up to 375 mg/kg/day) and rats (at oral doses up to 1000 mg/kg/day). In both species, no treatment-related embryo-fetal effects, including malformations, were observed. In addition, no treatment effects were observed in a separate pre- and postnatal study performed in rats at oral doses up to 500 mg/kg/day. The systemic exposures achieved in these animal studies were equivalent to those at the recommended human dose (400 mg/day).

- Placental and breast milk passage
  There are no data on whether etravirine crosses the placenta or is excreted in breast milk in humans.

- Human studies in pregnancy
  No adequate and well-controlled studies of etravirine use in pregnant women have been conducted and very limited case report data are available on etravirine use in pregnancy. One small study described use of etravirine in combination with darunavir/ritonavir and other ARV drugs in four pregnant women; PK sampling was done to determine etravirine plasma concentration during the third trimester.[1] PK data from these women were similar to those in non-pregnant adults. Data on etravirine in postpartum cord blood and concurrent maternal plasma specimens were available for one patient with values of 112 ng/mL and 339 ng/mL (cord/maternal blood ratio 0.33). No maternal, fetal, or neonatal toxicity was reported; one infant was born with a small accessory auricle on the right ear with no other malformations; no birth defects were noted in the other children. Placental passage of etravirine was noted in another report of use of etravirine, darunavir/ritonavir, and enfuvirtide in a pregnant woman who gave birth to twins (cord blood levels 414 ng/mL in Twin 1 and 345 ng/mL in Twin 2).[2] In a separate report on two women receiving etravirine, darunavir/ritonavir, and raltegravir during pregnancy, no perinatal transmission of HIV or congenital abnormalities were observed.[3]

## References


1. Izurieta P, Kakuda TN, Feys C, Witek J. Safety and pharmacokinetics of etravirine in pregnant HIV-1-infected women. *HIV Med*. Apr 2011;12(4):257-258. Available at http://www.ncbi.nlm.nih.gov/pubmed/21371239.
2. Furco A, Gosrani B, Nicholas S, et al. Successful use of darunavir, etravirine, enfuvirtide and tenofovir/emtricitabine in pregnant woman with multiclass HIV resistance. *AIDS*. Jan 28 2009;23(3):434-435. Available at http://www.ncbi.nlm.nih.gov/pubmed/19188762.
3. Jaworsky D, Thompson C, Yudin MH, et al. Use of newer antiretroviral agents, darunavir and etravirine with or without raltegravir, in pregnancy: a report of two cases. *Antivir Ther*. 2010;15(4):677-680. Available at http://www.ncbi.nlm.nih.gov/pubmed/20587860.


***Nevirapine (Viramune, NVP)*** is classified as FDA Pregnancy Category B.

**(Last updated July 31, 2012; last reviewed July 13, 2012)**

- Animal carcinogenicity studies
  Nevirapine showed no evidence of mutagenic or clastogenic activity in a battery of *in vitro* and *in vivo* studies. Hepatocellular adenomas and carcinomas were increased at all doses in male mice and rats and at higher doses in female mice and rats. Systemic exposure at all doses studied was lower than systemic exposure in humans receiving therapeutic nevirapine doses. Given the lack of genotoxic activity of nevirapine, the relevance to humans of hepatocellular neoplasms in nevirapine-treated mice and rats is unknown.

- Reproduction/fertility
  Evidence of impaired fertility was seen in female rats at nevirapine doses providing systemic exposure comparable to human therapeutic exposure.

- Teratogenicity/developmental toxicity
  Teratogenic effects of nevirapine have not been observed in reproductive studies with rats and rabbits at systemic exposures approximately equivalent to or 50% greater than the recommended human dose (based on AUC). In rats, however, a significant decrease in fetal weight occurred at doses producing systemic concentrations approximately 50% higher than human therapeutic exposure.

  In the Antiretroviral Pregnancy Registry, sufficient numbers of first-trimester exposures to nevirapine in

humans have been monitored to be able to detect at least a 1.5-fold increase in risk of overall birth defects and a 2-fold increase in risk of birth defects in the more common classes, cardiovascular and genitourinary systems. No such increase in birth defects has been observed with nevirapine. Among cases of first-trimester nevirapine exposure reported to the Antiretroviral Pregnancy Registry, the prevalence of birth defects was 2.7% (28 of 1,020 births; 95% CI, 1.8%–4.0 %) compared with a total prevalence of 2.7% in the U.S. population, based on Centers for Disease Control and Prevention surveillance.[1]

- Placental and breast milk passage

  Nevirapine crosses the placenta and achieves neonatal blood concentrations equivalent to that in the mother (cord-to-maternal blood ratio approximately 0.90).[2] Nevirapine is excreted into human breast milk; the median concentration in 4 breast milk samples obtained from 3 women during the first week after delivery was approximately 76% (range 54%–104%) of serum levels.[2] In 19 women receiving combination therapy with nevirapine, lamivudine, and zidovudine, breast milk nevirapine concentration was 6,795 ng/mL, which was 0.67 times that of maternal serum.[3] Median nevirapine breast milk concentration was 4,564 ng/mL in a Kenyan study of 67 HIV-infected nursing mothers receiving a combination of zidovudine, lamivudine, and nevirapine.[3] The median nevirapine concentration was 734 ng/mL in the infants who received the drug only via breast milk.

- Human studies in pregnancy

  *Short-Term Peripartum Prophylaxis:*

  A Phase I study (PACTG 250) evaluated the safety and PKs of nevirapine administered to infected pregnant women as a single 200-mg dose at the onset of labor and as a single 2-mg/kg dose to infants aged 48 to 72 hours.[2] No adverse effects were seen in the women or the infants.

  The PK parameters of intrapartum nevirapine were similar in pregnant women and in non-pregnant adults, but variability was increased during pregnancy. Nevirapine elimination was prolonged in the infants. The regimen maintained serum concentrations associated with antiviral activity in the infants for the first week of life.

  The safety, toxicity, and PKs of nevirapine were also studied in HIV-infected pregnant women beginning chronic therapy late in the third trimester and their infants.[4] Initial-dose PK profiles in pregnant women were similar to those seen in non-pregnant adults. Serum nevirapine concentrations fell below the 100 ng/mL target concentration by Day 7 of life in four of eight infants, suggesting that nevirapine elimination was accelerated in infants whose mothers received chronic nevirapine administration compared with newborns whose mothers received only a single intrapartum dose.

  The HIVNET 012 study in Uganda compared nevirapine (200 mg orally to the mother at the onset of labor and 2 mg/kg to the neonate within 72 hours of birth) with zidovudine (600 mg orally to the mother at the onset of delivery and 300 mg every 3 hours until delivery, and 4 mg/kg orally twice daily for the first 7 days of life to the neonate). In this study, nevirapine lowered the risk of transmission of HIV by nearly 50% during the first 14 to 16 weeks of life compared with zidovudine.[5] However, the women in this African trial were not receiving any other ARV drugs.

  In the United States, most infected women who know their HIV status during pregnancy receive combination ARV prophylaxis regimens, usually including zidovudine, as well as intravenous zidovudine during delivery, with 6 weeks of zidovudine given to their infant. A Phase III perinatal trial (PACTG 316) conducted in the United States, Europe, the Bahamas, and Brazil evaluated whether the HIVNET 012 single-dose nevirapine regimen in combination with standard combination prophylaxis regimens (at minimum the PACTG 076 zidovudine regimen; 77% of women in the trial received combination ARV

regimens) would provide additional benefits in reducing transmission. Transmission was not significantly different between those who received single-dose nevirapine (1.4%) and those who did not (1.6%).[6] Therefore, use of the single-dose nevirapine regimen is not recommended in women receiving combination regimens in the United States.

*Longer-Term Antenatal Combination Therapy* (See also Nevirapine and Hepatic/Rash Toxicity):

The PKs of nevirapine have been evaluated in pregnant women receiving nevirapine as part of ART during pregnancy. A study that determined nevirapine PKs in 26 women during pregnancy (7 second trimester, 19 third trimester) and again in the same women 4 to 12 weeks after delivery found that pregnancy did not alter nevirapine PK parameters.[7] In contrast, nevirapine clearance was 20% greater, AUC was 28% lower, and maximum plasma concentration was 30% lower in 16 pregnant women compared with 13 non-pregnant women, based on nevirapine PK data from a therapeutic drug monitoring program that included 12-hour sampling.[8]

Severe, life-threatening, and in some cases fatal hepatotoxicity, including fulminant and cholestatic hepatitis, hepatic necrosis, and hepatic failure and severe, life-threatening hypersensitivity skin reactions, including Stevens-Johnson syndrome, have been reported in HIV-infected patients receiving nevirapine in combination with other drugs for treatment of HIV disease and in a small number of individuals receiving nevirapine as part of a combination regimen for post-exposure prophylaxis of nosocomial or sexual exposure to HIV.[9] These toxicities have not been reported in women or infants receiving two-dose nevirapine (the HIVNET 012 regimen) for prevention of perinatal transmission. The greatest risk of severe rash or hepatic events occurs during the first 6 to 18 weeks of therapy, although the risk of toxicity continues past this period and monitoring should continue at frequent intervals.

Incidence of severe nevirapine-associated skin rash has been reported to be 5.5 to 7.3 times more common in women than men and has been reported in pregnant women.[10-12] Other studies have found that hepatic adverse events with systemic symptoms (often rash) were 3.2-fold more common in women than men.[13] Several studies suggest that the degree of risk of hepatic toxicity varies with CD4 T-lymphocyte (CD4-cell) count. In a summary analysis of data from 17 clinical trials of nevirapine therapy, women with CD4 counts >250 cells/mm$^3$ were 9.8 times more likely than women with lower CD4-cell counts to experience symptomatic, often rash-associated, nevirapine-related hepatotoxicity.[13] Higher CD4-cell counts have also been associated with increased risk of severe nevirapine-associated skin rash.[11] Rates of hepatotoxicity and rash similar to those in U.S. studies have been seen in international cohorts of non-pregnant women but not in association with CD4-cell counts >250 cells/mm$^3$.[14] In general, in controlled clinical trials, clinical hepatic events, regardless of severity, occurred in 4.0% (range 2.5%–11.0%) of patients who received nevirapine; however, the risk of nevirapine-associated liver failure or hepatic mortality has been lower, in the range of 0.04% to 0.40%.[13, 15] Severe or life-threatening rash occurs in approximately 2% of patients receiving nevirapine.[15]

Although deaths as a result of hepatic failure have been reported in HIV-infected pregnant women receiving nevirapine as part of a combination ARV regimen, it is uncertain if pregnancy increases the risk of hepatotoxicity in women receiving nevirapine or other ARV drugs.[16] In an analysis of two multicenter prospective cohorts, pregnancy itself was a risk factor for liver enzyme elevations (RR 4.7; 95% CI, 3.4–6.5), although nevirapine use was not, regardless of pregnancy status.[17] Additional data from the same cohorts did not show any increased risk of hepatotoxicity in HIV-infected pregnant women receiving nevirapine-based ART versus non-nevirapine-based ART.[18] In a cohort of 612 pregnant and non-pregnant women starting nevirapine-based therapy, CD4-cell count at initiation of therapy but not liver enzyme elevation was a predictor of rash; pregnancy was not an independent risk factor for the development of toxicity.[19] These data suggest that nevirapine is no more toxic in pregnant women than in non-pregnant women.

Women initiating nevirapine with CD4-cell counts >250 cells/mm$^3$, including pregnant women receiving ARV drugs solely for prevention of transmission, are at increased risk of developing symptomatic, often rash-associated, nevirapine-related hepatotoxicity, which can be severe, life threatening, and in some cases fatal.[20] Therefore, nevirapine should be used as a component of a combination regimen in this setting only if the benefit clearly outweighs the risk. Women with CD4-cell counts <250/mm$^3$ can receive nevirapine-based regimens, and women who become pregnant while taking nevirapine and who are tolerating their regimens well can continue therapy, regardless of CD4-cell count. Hepatic toxicity has not been seen in women receiving single-dose nevirapine during labor for prevention of perinatal transmission of HIV.

Because pregnancy itself can mimic some of the early symptoms of hepatotoxicity, health care providers caring for women receiving nevirapine during pregnancy should be aware of this potential complication. Frequent and careful monitoring of clinical symptoms and hepatic transaminases (that is, alanine aminotransferase [ALT] and aspartate aminotransferase [AST]) is necessary, particularly during the first 18 weeks of therapy. Some clinicians measure serum transaminases at baseline, every 2 weeks for the first month, monthly through 4 months, and every 1 to 3 months thereafter (*Adult Antiretroviral Guidelines*); in patients with pre-existing liver disease, monitoring should be performed more frequently when initiating therapy and monthly thereafter.[21] Transaminase levels should be checked in all women who develop a rash while receiving nevirapine. Patients who develop suggestive clinical symptoms accompanied by elevation in serum transaminase levels (ALT and/or AST) or have asymptomatic but severe transaminase elevations should stop nevirapine and not receive the drug in the future.

## References


1. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
2. Mirochnick M, Fenton T, Gagnier P, et al. Pharmacokinetics of nevirapine in human immunodeficiency virus type 1-infected pregnant women and their neonates. Pediatric AIDS Clinical Trials Group Protocol 250 Team. *J Infect Dis*. Aug 1998;178(2):368-374. Available at http://www.ncbi.nlm.nih.gov/pubmed/9697716.
3. Shapiro RL, Holland DT, Capparelli E, et al. Antiretroviral concentrations in breast-feeding infants of women in Botswana receiving antiretroviral treatment. *J Infect Dis*. Sep 1 2005;192(5):720-727. Available at http://www.ncbi.nlm.nih.gov/pubmed/16088821.
4. Mirochnick M, Siminski S, Fenton T, Lugo M, Sullivan JL. Nevirapine pharmacokinetics in pregnant women and in their infants after in utero exposure. *Pediatr Infect Dis J*. Aug 2001;20(8):803-805. Available at http://www.ncbi.nlm.nih.gov/pubmed/11734746.
5. Guay LA, Musoke P, Fleming T, et al. Intrapartum and neonatal single-dose nevirapine compared with zidovudine for prevention of mother-to-child transmission of HIV-1 in Kampala, Uganda: HIVNET 012 randomised trial. *Lancet*. Sep 4 1999;354(9181):795-802. Available at http://www.ncbi.nlm.nih.gov/pubmed/10485720.
6. Dorenbaum A, Cunningham CK, Gelber RD, et al. Two-dose intrapartum/newborn nevirapine and standard antiretroviral therapy to reduce perinatal HIV transmission: a randomized trial. *JAMA*. Jul 10 2002;288(2):189-198. Available at http://www.ncbi.nlm.nih.gov/pubmed/12095383.
7. Capparelli EV, Aweeka F, Hitti J, et al. Chronic administration of nevirapine during pregnancy: impact of pregnancy on pharmacokinetics. *HIV Med*. Apr 2008;9(4):214-220. Available at http://www.ncbi.nlm.nih.gov/pubmed/18366444.
8. von Hentig N, Carlebach A, Gute P, et al. A comparison of the steady-state pharmacokinetics of nevirapine in men, nonpregnant women and women in late pregnancy. *Br J Clin Pharmacol*. Nov 2006;62(5):552-559. Available at http://www.ncbi.nlm.nih.gov/pubmed/17061962.

9. Patel SM, Johnson S, Belknap SM, Chan J, Sha BE, Bennett C. Serious adverse cutaneous and hepatic toxicities associated with nevirapine use by non-HIV-infected individuals. *J Acquir Immune Defic Syndr*. Feb 1 2004;35(2):120-125. Available at http://www.ncbi.nlm.nih.gov/pubmed/14722442.

10. Mazhude C, Jones S, Murad S, Taylor C, Easterbrook P. Female sex but not ethnicity is a strong predictor of non-nucleoside reverse transcriptase inhibitor-induced rash. *AIDS*. Jul 26 2002;16(11):1566-1568. Available at http://www.ncbi.nlm.nih.gov/pubmed/12131201.

11. Bersoff-Matcha SJ, Miller WC, Aberg JA, et al. Sex differences in nevirapine rash. *Clin Infect Dis*. Jan 2001;32(1):124-129. Available at http://www.ncbi.nlm.nih.gov/pubmed/11118391.

12. Knudtson E, Para M, Boswell H, Fan-Havard P. Drug rash with eosinophilia and systemic symptoms syndrome and renal toxicity with a nevirapine-containing regimen in a pregnant patient with human immunodeficiency virus. *Obstet Gynecol*. May 2003;101(5 Pt 2):1094-1097. Available at http://www.ncbi.nlm.nih.gov/pubmed/12738113.

13. Stern JO, Robinson PA, Love J, Lanes S, Imperiale MS, Mayers DL. A comprehensive hepatic safety analysis of nevirapine in different populations of HIV infected patients. *J Acquir Immune Defic Syndr*. Sep 2003;34(Suppl 1):S21-33. Available at http://www.ncbi.nlm.nih.gov/pubmed/14562855.

14. Peters PJ, Stringer J, McConnell MS, et al. Nevirapine-associated hepatotoxicity was not predicted by CD4 count ≥250 cells/muL among women in Zambia, Thailand and Kenya. *HIV Med*. Nov 2010;11(10):650-660. Available at http://www.ncbi.nlm.nih.gov/pubmed/20659176.

15. Boehringer-Ingelheim Pharmaceuticals Inc. Viramune drug label. Revised March 25, 2011. Available at http://www.accessdata.fda.gov/drugsatfda_docs/label/2011/201152s000lbl.pdf. Accessed on June 25, 2012.

16. Lyons F, Hopkins S, Kelleher B, et al. Maternal hepatotoxicity with nevirapine as part of combination antiretroviral therapy in pregnancy. *HIV Med*. May 2006;7(4):255-260. Available at http://www.ncbi.nlm.nih.gov/pubmed/16630038.

17. Ouyang DW, Shapiro DE, Lu M, et al. Increased risk of hepatotoxicity in HIV-infected pregnant women receiving antiretroviral therapy independent of nevirapine exposure. *AIDS*. Nov 27 2009;23(18):2425-2430. Available at http://www.ncbi.nlm.nih.gov/pubmed/19617813.

18. Ouyang DW, Brogly SB, Lu M, et al. Lack of increased hepatotoxicity in HIV-infected pregnant women receiving nevirapine compared with other antiretrovirals. *AIDS*. Jan 2 2010;24(1):109-114. Available at http://www.ncbi.nlm.nih.gov/pubmed/19926957.

19. Aaron E, Kempf MC, Criniti S, et al. Adverse events in a cohort of HIV infected pregnant and non-pregnant women treated with nevirapine versus non-nevirapine antiretroviral medication. *PLoS One*. 2010;5(9):e12617. Available at http://www.ncbi.nlm.nih.gov/pubmed/20838641.

20. Grimbert S, Fisch C, Deschamps D, et al. Effects of female sex hormones on mitochondria: possible role in acute fatty liver of pregnancy. *Am J Physiol*. Jan 1995;268(1 Pt 1):G107-115. Available at http://www.ncbi.nlm.nih.gov/pubmed/7840191.

21. Kontorinis N, Dieterich DT. Toxicity of non-nucleoside analogue reverse transcriptase inhibitors. *Semin Liver Dis*. May 2003;23(2):173-182. Available at http://www.ncbi.nlm.nih.gov/pubmed/12800070.

***Rilpivirine (Edurant, RPV)*** is classified as FDA Pregnancy Category B.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies

  Rilpivirine was neither mutagenic nor clastogenic in a series of *in vitro* and animal *in vivo* screening tests. Rilpivirine was not carcinogenic in rats when administered at doses 3 times higher than exposure in humans at the recommended dose of 25 mg once daily. Hepatocellular neoplasms were observed in both male and female mice at doses 21 times that of human therapeutic exposure; the observed hepatocellular findings in mice may be rodent specific.[1]

- Reproduction/fertility
  No effect on fertility was observed when rilpivirine was tested in rats at maternal doses up to 400 mg/kg/day, resulting in systemic drug exposure equivalent to 40 times the recommended human dose.

- Teratogenicity/developmental toxicity
  No evidence of embryonic or fetal toxicity or an effect on reproductive function was observed in rat and rabbit dams treated with rilpivirine during pregnancy and lactation at doses 15 and 70 times higher, respectively, than exposure in humans at the recommended dose of 25 mg once daily.

- Placental and breast milk passage
  No data exist on whether rilpivirine crosses the placenta or is excreted in breast milk in humans. Studies in lactating rats and their offspring indicate that rilpivirine is present in rat milk.

- Human studies in pregnancy
  No adequate and well-controlled studies of rilpivirine use in pregnant women have been conducted.

## Reference

1. Tibotec. Edurant (rilpivirine) drug label. 2011. Available at http://www.accessdata.fda.gov/drugsatfda_docs/label/2011/202022s000lbl.pdf. Accessed on June 25, 2012.

## Protease Inhibitors

| Glossary of Terms for Supplement |
|---|
| **Carcinogenic** = producing or tending to produce cancer<br>• Some agents, such as certain chemicals or forms of radiation, are both mutagenic and clastogenic.<br>• Genetic mutations and/or chromosomal damage can contribute to cancer formation. |
| **Clastogenic** = causing disruption of or breakages in chromosomes |
| **Genotoxic** = damaging to genetic material such as DNA and chromosomes |
| **Mutagenic** = inducing or capable of inducing genetic mutation |
| **Teratogenic** = interfering with fetal development and resulting in birth defects |

Ten protease inhibitors (PIs) are currently approved (amprenavir is no longer available in the United States). Data are available from clinical trials in human pregnancy for atazanavir, lopinavir/ritonavir, nelfinavir, ritonavir, and saquinavir. Data in pregnancy are limited for darunavir, fosamprenavir, and indinavir. Very limited data in pregnancy are available for tipranavir.

For information regarding the PI class of drugs and potential metabolic complications during pregnancy and pregnancy outcome, see Protease Inhibitor Therapy and Hyperglycemia and Combination Antiretroviral Therapy and Pregnancy Outcome in the perinatal guidelines.

***Amprenavir (Agenerase, APV)*** is no longer available in the United States.
**(Last updated September 14, 2011; last reviewed July 31, 2012)**

***Atazanavir (Reyataz, ATV)*** is classified as Food and Drug Administration (FDA) Pregnancy Category B.
**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  In *in vitro* and *in vivo* assays, atazanavir shows evidence of clastogenicity but not mutagenicity. Two-year carcinogenicity studies in mice and rats were conducted with atazanavir. In female mice, the incidence of benign hepatocellular adenomas was increased at systemic exposures 2.8- to 2.9-fold higher than those in humans at the recommended therapeutic dose (300 mg/day atazanavir boosted with 100 mg/kg/day ritonavir). There were no increases in the incidence of tumors in male mice at any dose. In rats, no significant positive trends in the incidence of neoplasms occurred at systemic exposures up to 1.1-fold (males) or 3.9-fold (females) higher than those in humans at the recommended therapeutic dose.

- Reproduction/fertility
  No effect of atazanavir on reproduction or fertility in male and female rodents was seen at systemic drug exposures. The area under the curve (AUC) at this exposure level in rats was 0.9-fold in males and 2.3-fold in females compared with the exposures achieved in humans at the recommended therapeutic dose.

- Teratogenicity/developmental toxicity
  In animal reproduction studies, there was no evidence of teratogenicity in offspring born to animals at systemic drug exposure levels (AUC) 0.7 (in rabbits) to 1.2 (in rats) times those observed at the human clinical dose (300 mg/day atazanavir boosted with 100 mg/day ritonavir). In developmental toxicity

studies in rats, maternal dosing that resulted in maternal toxicity and produced systemic drug exposure 1.3 times the human exposure also resulted in weight loss or suppression of weight gain in the offspring. However, offspring were unaffected at lower maternal doses that produced systemic drug exposure equivalent to that observed in humans at the recommended therapeutic dose.

In a retrospective analysis from London of atazanavir used in 31 women during 33 pregnancies (20 of whom were receiving atazanavir at conception), there were 2 miscarriages at 12 and 16 weeks, 26 infants born, and 5 women still pregnant.[1] No infant required phototherapy and no birth defects were seen; none of the infants was HIV infected. In the Antiretroviral Pregnancy Registry, sufficient numbers of first-trimester exposure to atazanavir in humans have been monitored to be able to detect at least a 2-fold increase in risk of overall birth defects. No such increase in birth defects has been observed with atazanavir. The prevalence of birth defects with first-trimester atazanavir exposure was 1.9% (13 of 669 births; 95% confidence interval [CI], 1.0%–3.3%) compared with a 2.7% total prevalence in the U.S. population, based on Centers for Disease Control and Prevention (CDC) surveillance.[2]

Elevation in indirect (unconjugated) bilirubin attributable to atazanavir-related inhibition of hepatic uridine diphosphate glucuronosyltransferase (UGT) enzyme occurs frequently during treatment with atazanavir. Studies have demonstrated that infants born to mothers who received atazanavir during pregnancy do not have pathologic or dangerous bilirubin elevations in the neonatal period.[1, 3-7]

- Placental and breast milk passage

  In studies of women receiving atazanavir/ritonavir-based combination therapy during pregnancy, cord blood atazanavir concentration averaged 13% to 21% of maternal serum levels at delivery.[3, 5, 6] Atazanavir is excreted in the milk of lactating rats. In a study of three women, the median ratio of breast milk atazanavir concentration to that in plasma was 13%.[8]

- Human studies in pregnancy

  Several studies have investigated the pharmacokinetics (PKs) of atazanavir with ritonavir in pregnancy. In some of these studies, virological results were also analyzed. Overall, most pregnant patients were able to achieve HIV RNA less than 50 copies/mL at time of delivery.[9] In some studies, almost all pregnant patients achieved HIV RNA <50 copies/mL at time of delivery.[4, 6, 7] In a retrospective study reporting trough atazanavir concentrations in 19 pregnant women receiving atazanavir 300 mg and ritonavir 100 mg/day at a median of 30 weeks' gestation (14 in the third trimester), all but 2 women had a trough atazanavir concentration >100 ng/mL.[1] Three studies have evaluated full PK profiles of atazanavir when administered daily as 300 mg with 100 mg ritonavir during pregnancy. In all of these studies, atazanavir AUC was lower during pregnancy than in historic data from HIV-infected non-pregnant patients.[3-5] In 1 of the 3 studies, there was no difference between atazanavir AUC during pregnancy and postpartum, but AUC at both times was lower than in non-pregnant HIV-infected historic controls.[3] In the other 2 studies, atazanavir AUC was 25% lower during pregnancy than in the same patients postpartum.[4, 5, 9] However, in both these studies (BMS AI424182 and IMPAACT P1026 atazanavir cohort), the postpartum AUC was elevated compared with non-pregnant HIV-infected historic control patients. For example, in study AI424182, 34 women were treated with 300 mg atazanavir plus 100 mg ritonavir at 4 to 12 weeks postpartum and were observed to have a 34% increase in geometric AUC compared with the historic control of HIV-infected, non-pregnant patients (62 µg*hr/mL vs. 46.1 µg*hr/mL respectively).[6] Because of the postpartum elevation in AUC in this study, the atazanavir drug label recommends that postpartum patients should be closely monitored for adverse events during the first 2 months after delivery.

  Although use of atazanavir with ritonavir combined with tenofovir and emtricitabine as a complete once-a-day dosing combination antiretroviral (ARV) regimen is becoming increasingly common in pregnancy, tenofovir reduces atazanavir exposure by 25% in non-pregnant adults.[10] This drug-drug interaction also is

present during pregnancy, with a 25% reduction in atazanavir AUC in pregnant women also receiving tenofovir compared with the same women postpartum and a 50% reduction compared with postpartum levels in women who did not receive tenofovir.[5]

Use of an increased dose of atazanavir of 400 mg with 100 mg ritonavir during pregnancy has been investigated in two studies.[4, 5] In both studies pregnant women receiving the increased dose without tenofovir had an atazanavir AUC equivalent to that seen in historic non-pregnant HIV-infected controls receiving standard-dose atazanavir without tenofovir. Pregnant women receiving the increased atazanavir dose with tenofovir had an AUC equivalent to that seen in non-pregnant HIV-infected patients receiving standard-dose atazanavir and tenofovir.[9]

In the prescribing information for atazanavir,[6] the dose recommended for most pregnant women is 300 mg with 100 mg of ritonavir. For additional details about dosing with interacting concomitant medications, please see Table 5 (Antiretroviral Drug Use in Pregnant HIV-Infected Women: Pharmacokinetic and Toxicity Data in Human Pregnancy and Recommendations for Use in Pregnancy).

Neonatal elevations in bilirubin have been reported in some—but not all—studies of infants born to mothers receiving atazanavir during pregnancy.[3-5] Phototherapy was needed to control hyperbilirubinemia in 5 of 29 infants in 1 study.[7] In study AI424182, 6 of 39 infants received phototherapy.[4] Decisions to use phototherapy to treat infants with hyperbilirubinemia frequently are subjective and guidelines for phototherapy of infants vary between countries, making it difficult, therefore, to compare the severity of hyperbilirubinemia between patients within a study and in different studies. Elevated neonatal bilirubin is more likely in infants with uridine diphosphate glucuronosyltransferase 1 genotypes associated with decreased UGT function.[4]

Hypoglycemia (glucose <40 mg/dL) that could not be attributed to maternal glucose intolerance, difficult delivery, or sepsis has been reported in 3 of 38 atazanavir-exposed infants with glucose samples collected in the first day of life. All three hypoglycemic infants' glucose samples were adequately collected and processed in a timely fashion (Bristol-Myers Squibb Reyataz product label). This finding of infant hypoglycemia is similar to a prior report in which 2 (both nelfinavir) of 14 infants exposed to PIs (nelfinavir, saquinavir, and indinavir) developed hypoglycemia in the first day of life.[11]

## References


1. Natha M, Hay P, Taylor G, et al. Atazanavir use in pregnancy: a report of 33 cases. Paper presented at: 14th Conference on Retoviruses and Opportunistic Infections (CROI); February 25-28, 2007; Los Angeles, CA. Abstract 750.
2. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
3. Ripamonti D, Cattaneo D, Maggiolo F, et al. Atazanavir plus low-dose ritonavir in pregnancy: pharmacokinetics and placental transfer. *AIDS*. Nov 30 2007;21(18):2409-2415. Available at http://www.ncbi.nlm.nih.gov/pubmed/18025877.
4. Conradie F, Zorrilla C, Josipovic D, et al. Safety and exposure of once-daily ritonavir-boosted atazanavir in HIV-infected pregnant women. *HIV Med*. 2011 Oct;12(9):570-9. Available at: http://www.ncbi.nlm.nih.gov/pubmed/21569187.
5. Mirochnick M, Best BM, Stek AM, et al. Atazanavir pharmacokinetics with and without tenofovir during pregnancy. *J Acquir Immune Defic Syndr*. Apr 15 2011;56(5):412-419. Available at http://www.ncbi.nlm.nih.gov/pubmed/21283017.
6. Bristol-Myers Squibb Company. Reyataz package insert. 2011; http://www.accessdata.fda.gov/drugsatfda_docs/label/2011/021567s025lbl.pdf. Accessed on June 27, 2012.

7. Mandelbrot L, Mazy F, Floch-Tudal C, et al. Atazanavir in pregnancy: impact on neonatal hyperbilirubinemia. *Eur J Obstet Gynecol Reprod Biol*. Jul 2011;157(1):18-21. Available at http://www.ncbi.nlm.nih.gov/pubmed/21492993.

8. Spencer L, Neely M, Mordwinkin N, et al. Intensive pharmacokinetics of zidovudine, lamivudine, and atazanavir and HIV-1 viral load in breast milk and plasma in HIV+ women receiving HAART. Paper presented at: 16th Conference on Retroviruses and Opportunistic Infections (CROI); February, 8-11, 2009; Montreal, Canada. Abstract 942.

9. Mirochnick M, Stek A, Capparelli EV, et al. Pharmacokinetics of increased dose atazanavir with and without tenofovir during pregnancy. Paper presented at: 12th International Workshop on Clinical Pharmacology of HIV Therapy; April 13-15, 2011; Miami, FL. Abstract O10.

10. Taburet AM, Piketty C, Chazallon C, et al. Interactions between atazanavir-ritonavir and tenofovir in heavily pretreated human immunodeficiency virus-infected patients. *Antimicrob Agents Chemother*. Jun 2004;48(6):2091-2096. Available at http://www.ncbi.nlm.nih.gov/pubmed/15155205.

11. Dinsmoor MJ, Forrest ST. Lack of an effect of protease inhibitor use on glucose tolerance during pregnancy. *Infect Dis Obstet Gynecol*. 2002;10(4):187-191. Available at http://www.ncbi.nlm.nih.gov/pubmed/12648312.

***Darunavir (Prezista, DRV)*** is classified as FDA Pregnancy Category C.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Darunavir was neither mutagenic nor clastogenic in a series of *in vitro* and animal *in vivo* screening tests. A dose-related increase in the incidence of hepatocellular adenomas and carcinomas was observed in both male and female mice and rats as well as an increase in thyroid follicular cell adenomas in male rats. The observed hepatocellular findings in rodents are considered to be of limited relevance to humans. Repeated administration of darunavir to rats caused hepatic microsomal enzyme induction and increased thyroid hormone elimination, which predispose rats, but not humans, to thyroid neoplasms. At the highest tested doses, the systemic exposures to darunavir (based on AUC) were between 0.4- and 0.7-fold (mice) and 0.7-and 1-fold (rats) of those observed in humans at the recommended therapeutic doses (600/100 mg twice daily or 800/100 mg/day).

- Reproduction/fertility
  No effects on fertility and early embryonic development were seen with darunavir in rats.

- Teratogenicity/developmental toxicity
  No embryotoxicity or teratogenicity was seen in mice, rats, or rabbits. Because of limited bioavailability of darunavir in animals and dosing limitation, the plasma exposures were approximately 50% (mice and rats) and 5% (rabbits) of those obtained in humans. In the rat pre- and postnatal development study, a reduction in pup weight gain was observed with darunavir alone or with ritonavir exposure via breast milk during lactation. In juvenile rats, single doses of darunavir (20 mg/kg–160 mg/kg at ages 5–11 days) or multiple doses of darunavir (40 mg/kg–1000 mg/kg at age 12 days) caused mortality. The deaths were associated with convulsions in some of the animals. Within this age range, exposures in plasma, liver, and brain were dose and age dependent and were considerably greater than those observed in adult rats. These findings were attributed to the ontogeny of the cytochrome P450 liver enzymes involved in the metabolism of darunavir and the immaturity of the blood-brain barrier. Sexual development, fertility, or mating performance of offspring was not affected by maternal treatment. Fewer than 200 first-trimester pregnancy exposures have been reported to the Antiretroviral Pregnancy Registry; therefore, no conclusions can be made about risk of birth defects.

- Placental and breast milk passage
  No animal studies of placental passage of darunavir have been reported. Although variable transplacental

transfer of darunavir has been observed in some case reports, in a study of 14 mother/infant pairs the median (range) ratio of darunavir concentration in cord blood to that in maternal delivery plasma was 24% (6%–58%).[1, 2, 3, 4, 5] Passage of darunavir into breast milk has been noted in rats. It is unknown if breast milk passage of darunavir occurs in humans.

- Human studies in pregnancy
  Currently, limited data exist about darunavir in pregnancy.[1-11] Three intensive PK studies of darunavir/ritonavir administered as 600 mg/100 mg twice a day or 800 mg/100 mg once a day during pregnancy demonstrate 17% to 35% reductions in darunavir plasma concentration during the third trimester compared with postpartum.[1, 4, 11] Because of low trough levels with once-daily dosing, twice-daily dosing of darunavir is recommended during pregnancy. A study of use of an increased twice-daily darunavir dose during pregnancy is under way. Darunavir plasma protein binding decreases during pregnancy, which increases the unbound plasma darunavir fraction and may partially mitigate the decrease in total darunavir concentration.[11]

## References


1. Capparelli EV, Best BM, Stek A, et al. Pharmacokinetics of darunavir once or twice daily during pregnancy and postpartum. Paper presented at: 3rd International Workshop on HIV Pediatrics; July 15-16, 2011; Rome, Italy. Abstract P72.
2. Ripamonti D, Cattaneo D, Cortinovis M, Maggiolo F, Suter F. Transplacental passage of ritonavir-boosted darunavir in two pregnant women. *Int J STD AIDS*. Mar 2009;20(3):215-216. Available at http://www.ncbi.nlm.nih.gov/pubmed/19255280.
3. Pinnetti C, Tamburrini E, Ragazzoni E, De Luca A, Navarra P. Decreased plasma levels of darunavir/ritonavir in a vertically infected pregnant woman carrying multiclass-resistant HIV type-1. *Antivir Ther*. 2010;15(1):127-129. Available at http://www.ncbi.nlm.nih.gov/pubmed/20167999.
4. Colbers A, Taylor G, et al. A comparison of the pharmacokinetics of tenofovir during pregnancy and post-partum. Paper presented at: 13th International Workshop on Clinical Pharmacology of HIV Therapy; April 16-18, 2012; Barcelona, Spain. Abstract P34.
5. Courbon E, Matheron S, et al. . Safety, efficacy, and pharmacokinetic of darunavir/ritonavir-containing regimen in pregnant HIV+ women. Paper presented at: 19th Conference on Retroviruses and Opportunistic Infections (CROI); March 5-8, 2012; Seattle, WA. Abstract 1011.
6. Jaworsky D, Thompson C, Yudin MH, et al. Use of newer antiretroviral agents, darunavir and etravirine with or without raltegravir, in pregnancy: a report of two cases. *Antivir Ther*. 2010;15(4):677-680. Available at http://www.ncbi.nlm.nih.gov/pubmed/20587860.
7. Ivanovic J, Bellagamba R, Nicastri E, et al. Use of darunavir/ritonavir once daily in treatment-naive pregnant woman: pharmacokinetics, compartmental exposure, efficacy and safety. *AIDS*. Apr 24 2010;24(7):1083-1084. Available at http://www.ncbi.nlm.nih.gov/pubmed/20386380.
8. Pacanowski J, Bollens D, Poirier JM, et al. Efficacy of darunavir despite low plasma trough levels during late pregnancy in an HIV-hepatitis C virus-infected patient. *AIDS*. Sep 10 2009;23(14):1923-1924. Available at http://www.ncbi.nlm.nih.gov/pubmed/19710560.
9. Furco A, Gosrani B, Nicholas S, et al. Successful use of darunavir, etravirine, enfuvirtide and tenofovir/emtricitabine in pregnant woman with multiclass HIV resistance. *AIDS*. Jan 28 2009;23(3):434-435. Available at http://www.ncbi.nlm.nih.gov/pubmed/19188762.
10. Sued O, Lattner J, Gun A, et al. Use of darunavir and enfuvirtide in a pregnant woman. *Int J STD AIDS*. Dec 2008;19(12):866-867. Available at http://www.ncbi.nlm.nih.gov/pubmed/19050223.

11. Zorrilla C, Wright R, et al. Total and unbound darunavir pharmacokinetics in HIV-1+ pregnant women. Paper presented at: 19th Conference on Retroviruses and Opportunistic Infections (CROI); March 5-8, 2012; Seattle, WA. Abstract 1012.

***Fosamprenavir (Lexiva, FPV)*** is classified as FDA Pregnancy Category C.
**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Fosamprenavir and amprenavir were neither mutagenic nor clastogenic in a series of *in vitro* and animal *in vivo* screening tests. Carcinogenicity studies of fosamprenavir showed an increase in incidence of hepatocellular adenomas and carcinomas at all doses tested in male mice and at the highest dose tested in female mice. In rats, the incidence of hepatocellular adenomas and thyroid follicular cell adenomas in males (all doses tested) and in females (two highest doses tested) was also increased. Repeat-dose studies in rats produced effects consistent with enzyme activation, which predisposes rats, but not humans, to thyroid neoplasms. In rats only there was an increase in interstitial cell hyperplasia at higher doses and an increase in uterine endometrial adenocarcinoma at the highest dose tested. The incidence of endometrial findings was slightly increased over concurrent controls but was within background range for female rats. Thus the relevance of the uterine endometrial adenocarcinomas is uncertain. Exposures in the carcinogenicity studies were 0.3- to 0.7-fold (mice) and 0.7- to 1.4-fold (rats) those in humans given 1400 mg twice daily of fosamprenavir alone, and 0.2- to 0.3-fold (mice) and 0.3- to 0.7-fold (rats) those in humans given 1400 mg once daily of fosamprenavir plus 200 mg ritonavir once daily or 0.1- to 0.3-fold (mice) and 0.3- to 0.6-fold (rats) those in humans given 700 mg of fosamprenavir plus 100 mg ritonavir twice daily.

- Reproduction/fertility
  No impairment of fertility or mating was seen in rats at doses providing 3 to 4 times the human exposure to fosamprenavir alone or exposure similar to that with fosamprenavir and ritonavir dosing in humans. At those doses, no effect was seen on the development or maturation of sperm in rats.

- Teratogenicity/developmental toxicity
  Fosamprenavir was studied in rabbits at 0.8 times and in rats at twice the exposure in humans to fosamprenavir alone and at 0.3 (rabbits) and 0.7 (rats) times the exposure in humans to the combination of fosamprenavir and ritonavir. In rabbits administered fosamprenavir (alone or in combination) the incidence of abortion was increased. In contrast, administration of amprenavir at a lower dose in rabbits was associated with fetal loss and an increased incidence of minor skeletal variations from deficient ossification of the femur, humerus, and trochlea. Fosamprenavir administered to pregnant rats (at twice human exposure) was associated with a reduction in pup survival and body weights in rats. F1 female rats had an increased time to successful mating, an increased length of gestation, a reduced number of uterine implantation sites per litter, and reduced gestational body weights compared with controls.

  The number of first-trimester exposures to fosamprenavir that have been monitored to date in the Antiretroviral Pregnancy Registry is insufficient to allow conclusions to be drawn regarding risk of birth defects.[1]

- Placental and breast milk passage
  In a small study of women receiving fosamprenavir during pregnancy, the median (range) amprenavir concentration in cord blood was 0.27 (0.09–0.60) mcg/mL and the median (range) ratio of amprenavir concentration in cord blood to that in maternal plasma at the time of delivery was 0.24 (0.06–0.93).[2]
  Amprenavir is excreted in the milk of lactating rats; it is not known if it is excreted in human milk.

- Human studies in pregnancy
  Very limited data exist on fosamprenavir in pregnant women. Fosamprenavir PK data have been reported

in 16 women during pregnancy and postpartum. Following standard dosing with fosamprenavir 700 mg and ritonavir 100 mg, amprenavir AUC and 12-hour trough concentrations were somewhat lower during pregnancy and higher postpartum compared with historical data. Amprenavir exposure during pregnancy appeared to be adequate for patients without PI resistance mutations.[2]

A pediatric liquid formulation of fosamprenavir has been approved for children older than age 2 years, but there is no dosing information for neonates.

## References


1. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
2. Capparelli EV, Stek A, Best B, et al. Boosted fosamprenavir pharmacokinetics during pregnancy. Paper presented at: 17th Conference on Retroviruses and Opportunistic Infections (CROI); February 16-19, 2010; San Francisco, CA. Abstract 908.


***Indinavir (Crixivan, IDV)*** is classified as FDA Pregnancy Category C.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Indinavir is neither mutagenic nor clastogenic in both *in vitro* and *in vivo* assays. No increased incidence of any tumor types occurred in long-term studies in mice. At the highest dose studied in rats (640 mg/kg/day or 1.3-fold higher than systemic exposure at human therapeutic doses), thyroid adenomas were seen in male rats.

- Reproduction/fertility
  No effect of indinavir has been seen on reproductive performance, fertility, or embryo survival in rats.

- Teratogenicity/developmental toxicity
  There has been no evidence of teratogenicity or treatment-related effects on embryonic/fetal survival or fetal weights of indinavir in rats, rabbits, or dogs at exposures comparable to or slightly greater than therapeutic human exposure. In rats, developmental toxicity manifested by an increase in supernumerary and cervical ribs was observed at doses comparable to those administered to humans. No treatment-related external or visceral changes were observed in rats. No treatment-related external, visceral, or skeletal changes were seen in rabbits (fetal exposure limited, approximately 3% of maternal levels) or dogs (fetal exposure approximately 50% of maternal levels). Indinavir was administered to pregnant Rhesus monkeys during the third trimester (at doses up to 160 mg/kg twice daily) and to neonatal Rhesus monkeys (at doses up to 160 mg/kg twice daily). When administered to neonates, indinavir exacerbated the transient physiologic hyperbilirubinemia seen in this species after birth; serum bilirubin values were approximately 4-fold greater than controls at 160 mg/kg twice daily. A similar exacerbation did not occur in neonates after *in utero* exposure to indinavir during the third trimester. In Rhesus monkeys, fetal plasma drug levels were approximately 1% to 2% of maternal plasma drug levels approximately 1 hour after maternal dosing at 40, 80, or 160 mg/kg twice daily.

  In the Antiretroviral Pregnancy Registry, sufficient numbers of first-trimester exposure to indinavir in humans have been monitored to be able to detect at least a 2-fold increase in risk of overall birth defects. No such increase in birth defects has been observed with indinavir. Among cases of first-trimester

indinavir exposure reported to the Antiretroviral Pregnancy Registry, the prevalence of birth defects was 2.1% (6 of 286 births; 95% CI, 0.8%–4.5%) compared with a 2.7% total prevalence in the U.S. population, based on CDC surveillance.[1]

- Placental and breast milk passage
  Significant placental passage of indinavir occurs in rats and dogs, but only limited placental transfer occurs in rabbits. In studies of pregnant women receiving unboosted indinavir and their infants, transplacental passage of indinavir was minimal.[2, 3] In a study of Thai pregnant women receiving indinavir boosted with ritonavir, median cord blood indinavir concentration was 0.12 mcg/mL, median maternal plasma delivery concentration was 0.96 mcg/mL, and the median ratio between indinavir concentrations in cord blood and maternal plasma at delivery was 12%.[4] Indinavir is excreted in the milk of lactating rats at concentrations slightly greater than maternal levels (milk-to-plasma ratio 1.26–1.45); it is not known if indinavir is excreted in human milk.

- Human studies in pregnancy
  The optimal dosing regimen for use of indinavir in pregnant patients has not been established. Two studies of the PKs of unboosted indinavir (800 mg 3 times a day) during pregnancy demonstrated significantly lower indinavir plasma concentrations during pregnancy than postpartum.[2, 5] Use of unboosted indinavir is not recommended in HIV-infected pregnant patients because of the substantially lower antepartum exposures observed in these studies and the limited experience in this patient population.

  Several reports investigate the use of indinavir with ritonavir boosting during pregnancy. In an intensive PK study of 26 Thai pregnant women receiving 400 mg indinavir/100 mg ritonavir twice a day, indinavir plasma concentrations were significantly lower during pregnancy than postpartum. The median trough indinavir concentration was 0.13 mcg/mL; 24% of subjects had trough concentrations below 0.10 mcg/mL, the target trough concentration used in therapeutic drug monitoring (TDM) programs; and 81% had RNA viral loads <50 copies/mL at delivery.[4] In a study of French pregnant women receiving 400 mg indinavir/100 mg ritonavir twice a day, the median indinavir trough concentration was 0.16 mcg/mL, 18% of subjects had trough concentrations below 0.12 mcg/mL, and 93% had HIV RNA level < 200 copies/mL at delivery.[6] In a small study of 2 women who received indinavir 800 mg and ritonavir 200 mg twice daily, third-trimester indinavir AUC exceeded that for historical non-pregnant controls.[7] Based on these data, indinavir can be used in pregnancy with ritonavir boosting. Given the limited data on appropriate dosing, HIV RNA levels and trough indinavir concentrations should be monitored during indinavir use in pregnancy.

## References


1. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
2. Unadkat JD, Wara DW, Hughes MD, et al. Pharmacokinetics and safety of indinavir in human immunodeficiency virus-infected pregnant women. *Antimicrob Agents Chemother.* Feb 2007;51(2):783-786. Available at http://www.ncbi.nlm.nih.gov/pubmed/17158945.
3. Mirochnick M, Dorenbaum A, Holland D, et al. Concentrations of protease inhibitors in cord blood after in utero exposure. *Pediatr Infect Dis J.* Sep 2002;21(9):835-838. Available at http://www.ncbi.nlm.nih.gov/pubmed/12352805.
4. Cressey TR, Kreitchman R, et al. Effect of pregnancy on pharmacokinetics of indinavir boosted ritonavir. Paper presented at: 13th International Workshop on Clinical Pharmacology of HIV Therapy; April 16-18, 2012; Barcelona, Spain. Abstract P37.
5. Hayashi S, Beckerman K, Homma M, Kosel BW, Aweeka FT. Pharmacokinetics of indinavir in HIV-positive pregnant women. *AIDS.* May 26 2000;14(8):1061-1062. Available at http://www.ncbi.nlm.nih.gov/pubmed/10853990.

6. Ghosn J, De Montgolfier I, Cornélie C, et al. Antiretroviral therapy with a twice-daily regimen containing 400 milligrams of indinavir and 100 milligrams of ritonavir in human immunodeficiency virus type 1-infected women during pregnancy. *Antimicrob Agents Chemother*. 2008 Apr;52(4):1542-4. Available at: http://www.ncbi.nlm.nih.gov/pubmed/18250187.

7. Kosel BW, Beckerman KP, Hayashi S, Homma M, Aweeka FT. Pharmacokinetics of nelfinavir and indinavir in HIV-1-infected pregnant women. *AIDS*. May 23 2003;17(8):1195-1199. Available at http://www.ncbi.nlm.nih.gov/pubmed/12819521.

## ***Lopinavir + Ritonavir (Kaletra, LPV/r)*** is classified as FDA Pregnancy Category C.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Neither lopinavir nor ritonavir was found to be mutagenic or clastogenic in a battery of *in vitro* and *in vivo* assays. The lopinavir/ritonavir combination was evaluated for carcinogenic potential by oral gavage administration to mice and rats for up to 104 weeks. Results showed an increased incidence of benign hepatocellular adenomas and increased combined incidence of hepatocellular adenomas plus carcinoma in male and female mice and male rats at doses that produced approximately 1.6 to 2.2 times (mice) and 0.5 times (rats) the human exposure at the recommended therapeutic dose of 400 mg/100 mg (based on $AUC_{0–24hr}$ measurement). Administration of lopinavir/ritonavir did not cause a statistically significant increase in incidence of any other benign or malignant neoplasm in mice or rats.

- Reproduction/fertility
  Lopinavir in combination with ritonavir at a 2:1 ratio produced no effects on fertility in male and female rats with exposures approximately 0.7-fold for lopinavir and 1.8-fold for ritonavir of the exposures in humans at the recommended therapeutic dose.

- Teratogenicity/developmental toxicity
  No evidence exists of teratogenicity with administration of lopinavir/ritonavir to pregnant rats or rabbits. In rats treated with a maternally toxic dosage (100 mg lopinavir/50 mg ritonavir/kg/day), embryonic and fetal developmental toxicities (early resorption, decreased fetal viability, decreased fetal body weight, increased incidence of skeletal variations, and skeletal ossification delays) were observed. Drug exposure in the pregnant rats was 0.7-fold for lopinavir and 1.8-fold for ritonavir of the exposures in humans at the recommended therapeutic dose. In a peri- and postnatal study in rats, a decrease in survival of pups between birth and postnatal Day 21 occurred with exposure to 40 mg lopinavir/20 mg ritonavir/kg/day or greater. In rabbits, no embryonic or fetal developmental toxicities were observed with a maternally toxic dosage, where drug exposure was 0.6-fold for lopinavir and 1-fold for ritonavir of the exposures in humans at the recommended therapeutic dose.

  In the Antiretroviral Pregnancy Registry, sufficient numbers of first-trimester exposures to lopinavir/ritonavir have been monitored for detection of at least a 2-fold increase in risk of overall birth defects. No such increase in birth defects has been observed with lopinavir/ritonavir. Among cases of first-trimester lopinavir/ritonavir exposure reported to the Antiretroviral Pregnancy Registry, the prevalence of birth defects was 2.4% (21 of 883; 95% CI, 1.5%–3.6%) compared with a total prevalence of 2.7% in the U.S. population, based on CDC surveillance.[1]

- Placental and breast milk passage
  Lopinavir crosses the human placenta; in the P1026s PK study, the average ratio of lopinavir concentration in cord blood to maternal plasma at delivery was 0.20 ± 0.13. For ritonavir, data in humans indicate only minimal transplacental passage (see ritonavir). Lopinavir and ritonavir are secreted in the breast milk of lactating rats; it is not known if either drug is excreted in human milk.

- Human studies in pregnancy

The original capsule formulation of lopinavir/ritonavir has been replaced by a new tablet formulation that is heat stable, has improved bioavailability characteristics, and does not have to be administered with food.[2, 3] PK studies of standard adult lopinavir/ritonavir doses (400 mg/100 mg twice a day ) using either the capsule or tablet formulations in pregnant women have demonstrated a reduction in lopinavir plasma concentrations during pregnancy of around 30% compared with that in non-pregnant adults.[4-6] Increasing lopinavir/ritonavir doses during pregnancy to either 533 mg/133 mg (capsules) or 600 mg/150 mg (tablets) results in lopinavir plasma concentrations equivalent to those seen in non-pregnant adults receiving standard doses.[7, 8] Reports of clinical experience suggest that most but not all pregnant women receiving standard lopinavir/ritonavir tablet dosing during pregnancy will have trough lopinavir concentrations that exceed 1.0 mcg/mL, the usual trough concentration target used in therapeutic drug monitoring programs for ARV-naive subjects, but not the higher trough concentrations recommended for PI-experienced subjects.[2, 5] Lopinavir plasma protein binding is reduced during pregnancy, but the resulting increase in free (unbound) drug is insufficient to make up for the reduction in total plasma lopinavir concentration associated with pregnancy.[9, 10]

These PK studies suggest that lopinavir/ritonavir doses should be increased to 600 mg/150 mg twice a day in all HIV-infected pregnant women during the second and third trimesters. If standard doses of lopinavir/ritonavir are used during pregnancy, virologic response and lopinavir drug concentrations, if available, should be monitored. An alternative strategy for increasing lopinavir/ritonavir exposure during pregnancy is to add a pediatric lopinavir/ritonavir tablet (100/25 mg) to the standard dose of two adult 200/50 mg tablets.[10] Once-daily dosing of lopinavir/ritonavir is not recommended in pregnancy because no data exist to address whether drug levels are adequate with such administration.

Lopinavir/ritonavir oral solution contains 42.4% (volume/volume) alcohol and 15.3% (weight/volume) propylene glycol. Reduced hepatic metabolic and kidney excretory function in newborns can lead to accumulation of lopinavir as well as alcohol and propylene glycol, resulting in adverse events such as serious cardiac, renal, metabolic, or respiratory problems. Preterm babies may be at increased risk because their metabolism and elimination of lopinavir, propylene glycol, and alcohol are further reduced. Postmarketing surveillance has identified 10 neonates (babies <4 weeks of age), 9 of whom were born prematurely, who received lopinavir/ritonavir and experienced life-threatening events.[11] In a separate report comparing 50 HIV-exposed newborns treated with lopinavir/ritonavir after birth to 108 HIV-exposed neonates treated with zidovudine alone, elevated concentrations of 17-hydoxyprogesterone and dehydroepiandrosterone-sulfate, consistent with impairment of 21α-hydroxylase activity, were seen only in the lopinavir-exposed infants. All term infants were asymptomatic but 3 of 8 preterm infants had life-threatening symptoms, including hyponatremia, hyperkalemia, and cardiogenic shock, consistent with adrenal insufficiency.[12] Lopinavir/ritonavir oral solution should not be administered to neonates before a postmenstrual age (first day of the mother's last menstrual period to birth, plus the time elapsed after birth) of 42 weeks and a postnatal age of at least 14 days has been attained.

## References


1. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
2. Khuong-Josses MA, Azerad D, Boussairi A, Ekoukou D. Comparison of lopinavir level between the two formulations (soft-gel capsule and tablet) in HIV-infected pregnant women. *HIV Clin Trials*. Jul-Aug 2007;8(4):254-255. Available at http://www.ncbi.nlm.nih.gov/pubmed/17720666.
3. Else LJ, Douglas M, Dickinson L, Back DJ, Khoo SH, Taylor GP. Improved oral bioavailability of lopinavir in melt-

extruded tablet formulation reduces impact of third trimester on lopinavir plasma concentrations. *Antimicrob Agents Chemother*. Feb 2012;56(2):816-824. Available at http://www.ncbi.nlm.nih.gov/pubmed/22106215.

4. Stek AM, Mirochnick M, Capparelli E, et al. Reduced lopinavir exposure during pregnancy. *AIDS*. Oct 3 2006;20(15):1931-1939. Available at http://www.ncbi.nlm.nih.gov/pubmed/16988514.
5. Bouillon-Pichault M, Jullien V, Azria E, et al. Population analysis of the pregnancy-related modifications in lopinavir pharmacokinetics and their possible consequences for dose adjustment. *J Antimicrob Chemother*. Jun 2009;63(6):1223-1232. Available at http://www.ncbi.nlm.nih.gov/pubmed/19389715.
6. Ramautarsing RA, van der Lugt J, Gorowara M, et al. Thai HIV-1-infected women do not require a dose increase of lopinavir/ritonavir during the third trimester of pregnancy. *AIDS*. Jun 19 2011;25(10):1299-1303. Available at http://www.ncbi.nlm.nih.gov/pubmed/21516029.
7. Mirochnick M, Best BM, Stek AM, et al. Lopinavir exposure with an increased dose during pregnancy. *J Acquir Immune Defic Syndr*. Dec 15 2008;49(5):485-491. Available at http://www.ncbi.nlm.nih.gov/pubmed/18989231.
8. Best BM, Stek AM, Mirochnick M, et al. Lopinavir tablet pharmacokinetics with an increased dose during pregnancy. *J Acquir Immune Defic Syndr*. Aug 2010;54(4):381-388. Available at http://www.ncbi.nlm.nih.gov/pubmed/20632458.
9. Aweeka FT, Stek A, Best BM, et al. Lopinavir protein binding in HIV-1-infected pregnant women. *HIV Med*. Apr 2010;11(4):232-238. Available at http://www.ncbi.nlm.nih.gov/pubmed/20002783.
10. Patterson KB, Dumond JB, Prince HA, et al. Pharmacokinetics of the LPV/r tablet in HIV-infected pregnant women: a longitudinal investigation of protein bound and unbound drug exposure with empiric dosage adjustment. Paper presented at: 18th Conference on Retroviruses and Opportunistic Infections (CROI); February 27-March 2, 2011; Boston, MA. Abstract 645.
11. Boxwell D, Cao K, Lewis L, Marcus K, Nikhar B. Neonatal toxicity of Kaletra oral solution: LPV, ethanol or prophylene glycol? Paper presented at: 18th Conference on Retroviruses and Opportunistic Infections (CROI); February 27-Mar 2 2011; Boston, MA. Abstract 708.
12. Simon A, Warszawski J, Kariyawasam D, et al. Association of prenatal and postnatal exposure to lopinavir-ritonavir and adrenal dysfunction among uninfected infants of HIV-infected mothers. *JAMA*. Jul 6 2011;306(1):70-78. Available at http://www.ncbi.nlm.nih.gov/pubmed/21730243.

***Nelfinavir (Viracept, NFV)*** is classified as FDA Pregnancy Category B.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Nelfinvair was neither mutagenic nor clastogenic in a series of *in vitro* and animal *in vivo* screening tests. However, incidence of thyroid follicular cell adenomas and carcinomas was increased over baseline in male rats receiving nelfinavir dosages of 300 mg/kg/day or higher (equal to a systemic exposure similar to that in humans at therapeutic doses) and female rats receiving 1000 mg/kg/day (equal to a systemic exposure 3-fold higher than that in humans at therapeutic doses).

- Reproduction/fertility
  No effect of nelfinavir has been seen on reproductive performance, fertility, or embryo survival in rats at exposures comparable to human therapeutic exposure. Additional studies in rats indicated that exposure to nelfinavir in females from midpregnancy through lactation had no effect on the survival, growth, and development of the offspring to weaning. Maternal exposure to nelfinavir also did not affect subsequent reproductive performance of the offspring.

- Teratogenicity/developmental toxicity
  No evidence of teratogenicity has been observed in pregnant rats at exposures comparable to human exposure and in rabbits with exposures significantly less than human exposure.

In the Antiretroviral Pregnancy Registry, sufficient numbers of first-trimester exposures to nelfinavir have been monitored to be able to detect at least a 2-fold increase in risk of overall birth defects. No such increase in birth defects has been observed with nelfinavir. Among cases of first-trimester nelfinavir exposure reported to the Antiretroviral Pregnancy Registry, prevalence of birth defects was 3.9% (47 of 1,204 births; 95% CI, 2.9%–5.2%) compared with a 2.7% total prevalence in the U.S. population, based on CDC surveillance.[1]

- Placental and breast milk transfer
  In a Phase I study in pregnant women and their infants (PACTG 353, see below), transplacental passage of nelfinavir was minimal.[2] In addition, in a study of cord blood samples from 38 women treated with nelfinavir during pregnancy, the cord blood nelfinavir concentration was less than the assay limit of detection in 24 (63%), and the cord blood concentration was low (median, 0.35 µg/mL) in the remaining 14 women.[3] Nelfinavir is excreted in the milk of lactating rats; it is not known if it is excreted in human milk.

- Human studies in pregnancy
  A Phase I/II safety and PK study (PACTG 353) of nelfinavir in combination with zidovudine and lamivudine was conducted in pregnant HIV-infected women and their infants.[2] In the first nine pregnant HIV-infected women enrolled in the study, nelfinavir administered at a dose of 750 mg three times daily produced drug exposures that were variable and generally lower than those reported in non-pregnant adults with both twice- and three-times-daily dosing. Therefore, the study was modified to evaluate an increased dose of nelfinavir given twice daily (1250 mg twice daily), which resulted in adequate levels of the drug in pregnancy. However, in two other small studies of women given 1250 mg nelfinavir twice daily in the second and third trimesters, drug concentrations in the second and third trimesters were somewhat lower than in non-pregnant women.[4, 5]

  In a PK study of combination therapy including the new nelfinavir 625-mg tablet formulation (given as 1250 mg twice daily) in 25 women at 30 to 36 weeks' gestation (and 12 at 6–12 weeks postpartum), peak levels and AUC were lower in the third trimester than postpartum.[6] Only 16% (4 of 25) of women during the third trimester and 8% (1 of 12) women postpartum had trough values greater than the suggested minimum trough of 800 ng/mL; however, viral load was <400 copies/mL in 96% of women in the third trimester and 86% postpartum.

  Some nelfinavir manufactured before 2008 may have contained low levels of ethyl methane sulfonate (EMS), a process-related impurity. EMS is teratogenic, mutagenic, and carcinogenic in animals, although no data exist in humans and no increase in birth defects has been observed in the Antiretroviral Pregnancy Registry. All nelfinavir manufactured and released since March 31, 2008, meets the new final EMS limits established by the FDA for prescribing to all patient populations, including pregnant women and pediatric patients.

## References


1. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
2. Bryson YJ, Mirochnick M, Stek A, et al. Pharmacokinetics and safety of nelfinavir when used in combination with zidovudine and lamivudine in HIV-infected pregnant women: Pediatric AIDS Clinical Trials Group (PACTG) Protocol 353. *HIV Clin Trials*. Mar-Apr 2008;9(2):115-125. Available at http://www.ncbi.nlm.nih.gov/pubmed/18474496.
3. Mirochnick M, Dorenbaum A, Holland D, et al. Concentrations of protease inhibitors in cord blood after *in utero*

exposure. *Pediatr Infect Dis J*. Sep 2002;21(9):835-838. Available at http://www.ncbi.nlm.nih.gov/pubmed/12352805.

4. Villani P, Floridia M, Pirillo MF, et al. Pharmacokinetics of nelfinavir in HIV-1-infected pregnant and nonpregnant women. *Br J Clin Pharmacol*. Sep 2006;62(3):309-315. Available at http://www.ncbi.nlm.nih.gov/pubmed/16934047.
5. Fang A, Valluri SR, O'Sullivan MJ, et al. Safety and pharmacokinetics of nelfinavir during the second and third trimesters of pregnancy and postpartum. *HIV Clin Trials*. Jan-Feb 2012;13(1):46-59. Available at http://www.ncbi.nlm.nih.gov/pubmed/22306587.
6. Read JS, Best BM, Stek AM, et al. Pharmacokinetics of new 625 mg nelfinavir formulation during pregnancy and postpartum. *HIV Med*. Nov 2008;9(10):875-882. Available at http://www.ncbi.nlm.nih.gov/pubmed/18795962.

***Ritonavir (Norvir, RTV)*** is classified as FDA Pregnancy Category B.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Ritonavir was neither mutagenic nor clastogenic in a series of *in vitro* and animal *in vivo* screening tests. Carcinogenicity studies in mice and rats have been completed. In male mice, a dose-dependent increase in adenomas of the liver and combined adenomas and carcinomas of the liver was observed at levels of 50, 100, or 200 mg/kg/day; based on AUC, exposure in male mice at the highest dose was approximately 0.3-fold that in male humans at the recommended therapeutic dose. No carcinogenic effects were observed in female mice with exposures 0.6-fold that of female humans at the recommended therapeutic dose. No carcinogenic effects were observed in rats at exposures up to 6% of recommended therapeutic human exposure.

- Reproduction/fertility
  No effect of ritonavir has been seen on reproductive performance or fertility in rats at drug exposures 40% (male) and 60% (female) of that achieved with human therapeutic dosing; higher doses were not feasible because of hepatic toxicity in the rodents.

- Teratogenicity/developmental toxicity
  No ritonavir-related teratogenicity has been observed in rats or rabbits. Developmental toxicity, including early resorptions, decreased body weight, ossification delays, and developmental variations such as wavy ribs and enlarged fontanelles, was observed in rats; however, these effects occurred only at maternally toxic dosages (exposure equivalent to 30% of human therapeutic exposure). In addition, a slight increase in cryptorchidism was also noted in rats at exposures equivalent to 22% of the human therapeutic dose. In rabbits, developmental toxicity (resorptions, decreased litter size, and decreased fetal weight) was observed only at maternally toxic doses (1.8 times human therapeutic exposure based on body surface area).

  In the Antiretroviral Pregnancy Registry, sufficient numbers of first-trimester exposures to ritonavir have been monitored to be able to detect at least a 2-fold increase in risk of overall birth defects. No such increase in birth defects has been observed with ritonavir. Among cases of first-trimester ritonavir exposure reported to the Antiretroviral Pregnancy Registry, the prevalence of birth defects was 2.2% (39 of 1,741 births; 95% CI, 1.6%–3.0%) compared with a total prevalence of 2.7% in the U.S. population, based on CDC surveillance.[1]

- Placental and breast milk transfer
  Transplacental passage of ritonavir has been observed in rats with fetal tissue-to-maternal-serum ratios >1.0 at 24 hours post-dose in mid- and late-gestation fetuses. In a human placental perfusion model, the clearance index of ritonavir was very low, with little accumulation in the fetal compartment and no accumulation in placental tissue.[2] In a Phase I study of pregnant women and their infants (PACTG 354, see below), transplacental passage of ritonavir was minimal.[3] Additionally, in a study of cord blood samples from six women treated with ritonavir during pregnancy, the cord blood concentration was less

than the assay limit of detection in 83% and was only 0.38 µg/mL in the remaining woman.[4] Ritonavir is excreted in the milk of lactating rats; it is unknown if it is excreted in human milk.

- Human studies in pregnancy
  A Phase I/II safety and PK study (PACTG 354) of ritonavir (500 or 600 mg twice daily) in combination with zidovudine and lamivudine in pregnant HIV-infected women and their infants showed lower levels of ritonavir during pregnancy than postpartum.[3] Ritonavir concentrations are also reduced during pregnancy versus postpartum when the drug is used at a low dose (100 mg) to boost the concentrations of other PIs.[5, 6]

## References


1. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
2. Casey BM, Bawdon RE. Placental transfer of ritonavir with zidovudine in the ex vivo placental perfusion model. *Am J Obstet Gynecol*. Sep 1998;179(3 Pt 1):758-761. Available at http://www.ncbi.nlm.nih.gov/pubmed/9757985.
3. Scott GB, Rodman JH, Scott WA, et al. Pharmacokinetic and virologic response to ritonavir (RTV) in combination with zidovudine (ZDV) and lamivudine (3TC) in HIV-10-infected pregnant women and their infants. Paper presented at: 9th Conference on Retroviruses and Opportunistic Infections (CROI); February 24-28, 2002; Seattle, WA. Abstract 794.
4. Mirochnick M, Dorenbaum A, Holland D, et al. Concentrations of protease inhibitors in cord blood after in utero exposure. *Pediatr Infect Dis J*. Sep 2002;21(9):835-838. Available at http://www.ncbi.nlm.nih.gov/pubmed/12352805.
5. Best BM, Stek AM, Mirochnick M, et al. Lopinavir tablet pharmacokinetics with an increased dose during pregnancy. *J Acquir Immune Defic Syndr.* Aug 2010;54(4):381-388. Available at http://www.ncbi.nlm.nih.gov/pubmed/20632458.
6. Mirochnick M, Best BM, Stek AM, et al. Atazanavir pharmacokinetics with and without tenofovir during pregnancy. *J Acquir Immune Defic Syndr.* Apr 15 2011;56(5):412-419. Available at http://www.ncbi.nlm.nih.gov/pubmed/21283017.


***Saquinavir (Invirase, SQV)*** is classified as FDA Pregnancy Category B.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Saquinavir was neither mutagenic nor clastogenic in a series of *in vitro* and animal *in vivo* screening tests. Carcinogenicity studies found no indication of carcinogenic activity in rats and mice administered saquinavir for approximately 2 years at plasma exposures approximately 60% of those obtained in humans at the recommended therapeutic dose (rats) and at exposures equivalent to those in humans at the recommended therapeutic dose (mice).

- Reproduction/fertility
  No effect of saquinavir has been seen on reproductive performance, fertility, or embryo survival in rats. Because of limited bioavailability of saquinavir in animals, the maximal plasma exposures achieved in rats were approximately 26% of those obtained in humans at the recommended clinical dose boosted with ritonavir.

- Teratogenicity/developmental toxicity
  No evidence of embryotoxicity or teratogenicity of saquinavir has been found in rabbits or rats. Because of limited bioavailability of saquinavir in animals and/or dosing limitations, the plasma exposures (AUC values) in the respective species were approximately 29% (using rat) and 21% (using rabbit) of those obtained in humans at the recommended clinical dose boosted with ritonavir.

Too few first-trimester saquinavir exposures have been monitored by the Antiretroviral Pregnancy Registry to be able to accurately calculate the prevalence of birth defects in exposed cases.[1]

- Placental and breast milk transfer
  Placental transfer of saquinavir in the rat and rabbit was minimal. In a Phase I study in pregnant women and their infants (PACTG 386, see below), transplacental passage of saquinavir was minimal.[2] In addition, in a study of cord blood samples from eight women treated with saquinavir during pregnancy, the cord blood concentration of saquinavir was less than the assay limit of detection in samples from all women.[3] Saquinavir is excreted in the milk of lactating rats; it is not known if it is excreted in human milk.

- Human studies in pregnancy
  Three studies have evaluated PKs of saquinavir-hard gel capsules (HGC) combined with low-dose ritonavir (saquinavir-HGC 1000 mg/ritonavir 100 mg given twice daily) in a total of 19 pregnant women; trough levels were greater than the target in all but 1 woman.[4, 5] In a small study of 2 women who received saquinavir-HGC 1200 mg/ritonavir 100 mg given once daily, trough levels were 285 and 684 ng/mL and the $AUC_{0–24}$ were 28,010 and 16,790 ng hour/mL, greater than the target AUC of 10,000 ng hour/mL.[6] Thus, the limited available data suggest that saquinavir-HGC 1000 mg/ritonavir 100 mg given twice daily should achieve adequate trough levels in HIV-infected pregnant women. Data are too limited to recommend once-daily dosing at present. However, a recent analysis of saquinavir HGC administered once daily at 1200 mg/100 mg ritonavir combined with various nucleoside reverse transcriptase inhibitors during 46 pregnancies demonstrated saquinavir levels greater than the target minimum plasma concentration in 46 (93.4%) of pregnancy episodes and undetectable viral load at delivery in 88% of episodes.[7] Target levels were achieved in the other 3 women with a dose of 1600 mg/100 mg. The drug was well tolerated.

  The PKs of the new 500-mg tablet formulation of saquinavir boosted with ritonavir in a dose of saquinavir 1000 mg/ritonavir 100 mg given twice daily were studied in 37 HIV-infected pregnant women at 20 and 33 weeks' gestation and 6 weeks postpartum; PK parameters were comparable during pregnancy and postpartum.[8] However, in a smaller study of saquinavir tablets boosted with ritonavir given to 14 HIV-infected pregnant women, the saquinavir exposure during the third trimester was reduced by about 50%, yet no woman experienced loss of virologic control and all but 1 maintained adequate trough levels of saquinavir.[9] Thus, it does not appear that any adjustment of saquinavir boosted with ritonavir is necessary during pregnancy.

  One study of a saquinavir/ritonavir-based combination ARV drug regimen in 42 women during pregnancy reported abnormal transaminase levels in 13 women (31%) within 2 to 4 weeks of treatment initiation, although the abnormalities were mild (toxicity Grade 1–2 in most, Grade 3 in 1 woman).[10]

## References


1. Antiretroviral Pregnancy Registry Steering Committee. Antiretroviral pregnancy registry international interim report for 1 Jan 1989 - 31 January 2012. Wilmington, NC: Registry Coordinating Center; 2012. Available at http://www.APRegistry.com.
2. Zorrilla CD, Van Dyke R, Bardeguez A, et al. Clinical response and tolerability to and safety of saquinavir with low-dose ritonavir in human immunodeficiency virus type 1-infected mothers and their infants. *Antimicrob Agents Chemother*. Jun 2007;51(6):2208-2210. Available at http://www.ncbi.nlm.nih.gov/pubmed/17420209.
3. Mirochnick M, Dorenbaum A, Holland D, et al. Concentrations of protease inhibitors in cord blood after *in utero* exposure. *Pediatr Infect Dis J*. Sep 2002;21(9):835-838. Available at http://www.ncbi.nlm.nih.gov/pubmed/12352805.

4. Hanlon M, O'Dea S, Woods S, et al. Evaluation of saquinavir/ritonavir based regimen for prevention of MTCT of HIV. Paper presented at: 13th Conference on Retroviruses and Opportunistic Infections (CROI); February 5-8, 2006; Denver, CO. Abstract 721.

5. Khan W, Hawkins DA, Moyle G, et al. Pharmacokinetics (PK), safety, tolerability and efficacy of saquinavir hard-gel capsules/ritonavir (SQV/r) plus 2 nucleosides in HIV-infected pregnant women. Paper presented at: XV International AIDS Conference; July 11-16, 2004; Bangkok, Thailand.

6. Lopez-Cortes LF, Ruiz-Valderas R, Pascual R, Rodriguez M, Marin Niebla A. Once-daily saquinavir-hgc plus low-dose ritonavir (1200/100 mg) in HIV-infected pregnant women: pharmacokinetics and efficacy. *HIV Clin Trials*. May-Jun 2003;4(3):227-229. Available at http://www.ncbi.nlm.nih.gov/pubmed/12815561.

7. Lopez-Cortes LF, Ruiz-Valderas R, Rivero A, et al. Efficacy of low-dose boosted saquinavir once daily plus nucleoside reverse transcriptase inhibitors in pregnant HIV-1-infected women with a therapeutic drug monitoring strategy. *Ther Drug Monit*. Apr 2007;29(2):171-176. Available at http://www.ncbi.nlm.nih.gov/pubmed/17417070.

8. van der Lugt J, Colbers A, Molto J, et al. The pharmacokinetics, safety and efficacy of boosted saquinavir tablets in HIV type-1-infected pregnant women. *Antivir Ther*. 2009;14(3):443-450. Available at http://www.ncbi.nlm.nih.gov/pubmed/19474478.

9. Martinez-Rebollar M, Lonca M, Perez I, et al. Pharmacokinetic study of saquinavir 500 mg plus ritonavir (1000/100 mg twice a day) in HIV-positive pregnant women. *Ther Drug Monit*. Dec 2011;33(6):772-777. Available at http://www.ncbi.nlm.nih.gov/pubmed/22105596.

10. Hanlon M, O'Dea S, Clarke S, et al. Maternal hepatotoxicity with boosted saquinavir as part of combination ART in pregnancy. Paper presented at: 14th Conference on Retoviruses and Opportunistic Infections (CROI); February 25-28, 2007; Los Angeles, CA. Abstract 753.

***Tipranavir (Aptivus, TPV)*** is classified as FDA Pregnancy Category C.

**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Tipranavir was neither mutagenic nor clastogenic in a battery of five *in vitro* and animal *in vivo* screening tests. Long-term carcinogenicity studies in mice and rats have been conducted with tipranavir. Mice were administered 30, 150, or 300 mg/kg/day tipranavir, 150/40 mg/kg/day tipranavir/ritonavir in combination, or 40 mg/kg/day ritonavir. Incidence of benign hepatocellular adenomas and combined adenomas/carcinomas was increased in females of all groups except females given the low dose of tipranavir. Such tumors also were increased in male mice at the high dose of tipranavir and in the tipranavir/ritonavir combination group. Incidence of hepatocellular carcinoma was increased in female mice given the high dose of tipranavir and in both sexes receiving tipranavir/ritonavir. The combination of tipranavir and ritonavir caused an exposure-related increase in this same tumor type in both sexes. The clinical relevance of the carcinogenic findings in mice is unknown. Systemic exposures in mice (based on AUC or maximum plasma concentration) at all dose levels tested were below those in humans receiving the recommended dose level. Rats were administered 30, 100, or 300 mg/kg/day tipranavir, 100/26.7 mg/kg/day tipranavir/ritonavir in combination, or 10 mg/kg/day ritonavir. No drug-related findings were observed in male rats. At the highest dose of tipranavir, an increased incidence of benign follicular cell adenomas of the thyroid gland was observed in female rats. Based on AUC measurements, exposure to tipranavir at this dose level in rats is approximately equivalent to exposure in humans at the recommended therapeutic dose. This finding is probably not relevant to humans because thyroid follicular cell adenomas are considered a rodent-specific effect secondary to enzyme induction.

- Reproduction/fertility
  Tipranavir had no effect on fertility or early embryonic development in rats at exposure levels similar to

human exposures at the recommended clinical dose (500/200 mg/day of tipranavir/ritonavir).

- Teratogenicity/developmental toxicity
  No teratogenicity was detected in studies of pregnant rats and rabbits at exposure levels approximately 1.1-fold and 0.1-fold human exposure. Fetal toxicity (decreased ossification and body weights) was observed in rats exposed to 400 mg/kg/day or more of tipranavir (~0.8-fold human exposure). Fetal toxicity was not seen in rats and rabbits at levels of 0.2-fold and 0.1-fold human exposures. In rats, no adverse effects on development were seen at levels of 40 mg/kg/day (~0.2-fold human exposure), but at 400 mg/kg/day (~0.8-fold human exposure), growth inhibition in pups and maternal toxicity were seen.

- Placental and breast milk transfer
  No animal studies of placental or breast milk passage of tipranavir have been reported. It is unknown if placental or breast milk passage of tipranavir occurs in humans.

- Human studies in pregnancy
  No studies of tipranavir have been completed in pregnant women or neonates. A case report with PK measurements of tipranavir used in a single pregnancy showed relatively high levels of tipranavir third trimester and relatively high placental transfer (0.41), as measured by cord blood.[1] It is unclear whether this finding will be applicable to other pregnancies.

## Reference


1. Weizsaecker K, Kurowski M, Hoffmeister B, Schurmann D, Feiterna-Sperling C. Pharmacokinetic profile in late pregnancy and cord blood concentration of tipranavir and enfuvirtide. *Int J STD AIDS*. May 2011;22(5):294-295. Available at http://www.ncbi.nlm.nih.gov/pubmed/21571982.

## Entry Inhibitors

| Glossary of Terms for Supplement |
|---|
| **Carcinogenic** = producing or tending to produce cancer<br>• Some agents, such as certain chemicals or forms of radiation, are both mutagenic and clastogenic.<br>• Genetic mutations and/or chromosomal damage can contribute to cancer formation. |
| **Clastogenic** = causing disruption of or breakages in chromosomes |
| **Genotoxic** = damaging to genetic material such as DNA and chromosomes |
| **Mutagenic** = inducing or capable of inducing genetic mutation |
| **Teratogenic** = interfering with fetal development and resulting in birth defects |

Two drugs have been approved in this new class of antiretroviral (ARV) drugs aimed at inhibiting viral binding or fusion of HIV to host target cells. Binding of the viral envelope glycoprotein (gp)120 to the CD4 receptor induces conformational changes that enable gp120 to interact with a chemokine receptor such as CCR5 or CXCR4 on the host cell; binding of gp120 to the coreceptor causes subsequent conformational changes in the viral transmembrane gp41, exposing the "fusion peptide" of gp41, which inserts into the cell membrane. A helical region of gp41, called HR1, then interacts with a similar helical region, HR2, on gp41, resulting in a "zipping" together of the two helices and mediating the fusion of cellular and viral membranes. Enfuvirtide, which requires subcutaneous (SQ) administration, is a synthetic 36-amino-acid peptide derived from a naturally occurring motif within the HR2 domain of viral gp41, and the drug binds to the HR1 region, preventing the HR1-HR2 interaction and correct folding of gp41 into its secondary structure, thereby inhibiting virus-cell fusion. Enfuvirtide was approved for use in combination with other ARV drugs to treat advanced HIV infection in adults and children 6 years of age or older. Maraviroc interferes with viral entry at the chemokine coreceptor level; it is a CCR5 coreceptor antagonist approved for combination therapy for HIV infection in adults infected with CCR5-tropic virus.

***Enfuvirtide (Fuzeon, T-20)*** is classified as Food and Drug Administration (FDA) Pregnancy Category B.
**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Enfuvirtide was neither mutagenic nor clastogenic in a series of *in vitro* and animal *in vivo* screening tests. Long-term animal carcinogenicity studies of enfuvirtide have not been conducted.

- Reproduction/fertility animal studies
  Reproductive toxicity has been evaluated in rats and rabbits. Enfuvirtide produced no adverse effects on fertility of male or female rats at doses up to 30 mg/kg/day administered SQ (1.6 times the maximum recommended adult human daily dose on an $m^2$ body surface area basis).

- Teratogenicity/developmental toxicity animal studies
  Studies in rats and rabbits revealed no evidence of harm to the fetus from enfuvirtide administered in doses up to 27 times and 3.2 times, respectively, the adult human daily dose on an $m^2$ basis.

- Placental and breast milk passage
  Studies of radiolabeled enfuvirtide administered to lactating rats indicated radioactivity in the milk;

however, it is not known if this reflected radiolabeled enfuvirtide or metabolites (such as amino acid and peptide fragments) of enfuvirtide. It is not known if enfuvirtide crosses the human placenta or is excreted in human milk. A published case report of two peripartum pregnant patients and their neonates and data from an *ex vivo* human placental cotyledon perfusion model suggest that enfuvirtide does not cross the placenta.[1, 2]

- Human studies in pregnancy
  Very limited data exist on the use of enfuvirtide in pregnant women.[1, 3-5] There is a single case report detecting no placental transfer of drug based on cord blood measurements.[5]

## References


1. Brennan-Benson P, Pakianathan M, Rice P, et al. Enfurvitide prevents vertical transmission of multidrug-resistant HIV-1 in pregnancy but does not cross the placenta. *AIDS*. Jan 9 2006;20(2):297-299. Available at http://www.ncbi.nlm.nih.gov/pubmed/16511429.
2. Ceccaldi PF, Ferreira C, Gavard L, Gil S, Peytavin G, Mandelbrot L. Placental transfer of enfuvirtide in the ex vivo human placenta perfusion model. *Am J Obstet Gynecol*. Apr 2008;198(4):433 e431-432. Available at http://www.ncbi.nlm.nih.gov/pubmed/18241815.
3. Cohan D, Feakins C, Wara D, et al. Perinatal transmission of multidrug-resistant HIV-1 despite viral suppression on an enfuvirtide-based treatment regimen. *AIDS*. Jun 10 2005;19(9):989-990. Available at http://www.ncbi.nlm.nih.gov/pubmed/15905684.
4. Meyohas MC, Lacombe K, Carbonne B, Morand-Joubert L, Girard PM. Enfuvirtide prescription at the end of pregnancy to a multi-treated HIV-infected woman with virological breakthrough. *AIDS*. Sep 24 2004;18(14):1966-1968. Available at http://www.ncbi.nlm.nih.gov/pubmed/15353987.
5. Weizsaecker K, Kurowski M, Hoffmeister B, Schurmann D, Feiterna-Sperling C. Pharmacokinetic profile in late pregnancy and cord blood concentration of tipranavir and enfuvirtide. *Int J STD AIDS*. May 2011;22(5):294-295. Available at http://www.ncbi.nlm.nih.gov/pubmed/21571982.


***Maraviroc (Selzentry, MVC)*** is classified as FDA Pregnancy Category B.

**(Last updated September 14, 2011; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Maraviroc was neither mutagenic nor clastogenic in a series of *in vitro* and animal *in vivo* screening tests. Long-term animal carcinogenicity studies found no increase in tumor incidence in mice (transgenic rasH2 mice) and rats at exposures up to 11-fold higher than experienced with human therapeutic exposure at the recommended clinical dose (300 mg twice daily).

- Reproduction/fertility animal studies
  Reproductive toxicity has been evaluated in rats. Maraviroc produced no adverse effects on fertility of male or female rats or sperm of male rats at exposures up to 20-fold higher than experienced with human therapeutic exposure at the recommended clinical dose (300 mg twice daily).

- Teratogenicity/developmental toxicity animal studies
  Studies in rats and rabbits revealed no evidence of harm to the fetus from maraviroc administered in doses up to 20-fold higher in rats and 5-fold higher in rabbits than experienced with human therapeutic exposure at the recommended clinical dose (300 mg twice daily).

- Placental and breast milk passage
  It is unknown if maraviroc crosses the placenta in humans. In a study of four macaques, a single oral

dose of 60 mg/kg or 100 mg/kg was given 2 hours before cesarean delivery. Median maternal concentration at delivery was 974 ng/mL (range 86–2830 ng/mL) and median infant concentration was 22 ng/mL (range 4–99 ng/mL) for a cord/maternal ratio of .023.[1] Maternal levels were detectable for 48 hours after a single dose, whereas infant levels were detectable for only 3.5 hours after birth. Studies in lactating rats indicate that maraviroc is extensively secreted into rat milk.

- Human studies in pregnancy
  No studies of maraviroc have been conducted in pregnant women or neonates.

- Additional concerns
  Although no increase in cancer has been observed with maraviroc, the drug has the potential to increase risk because of its mechanism of action and possible effects on immune surveillance.

## Reference


1. Winters MA, Van Rompay KK, Kashuba AD, Shulman NS, Holodniy M. Maternal-fetal pharmacokinetics and dynamics of a single intrapartum dose of maraviroc in rhesus macaques. *Antimicrob Agents Chemother*. Oct 2010;54(10):4059-4063. Available at http://www.ncbi.nlm.nih.gov/pubmed/20696881.

## Integrase Inhibitors

| Glossary of Terms for Supplement |
|---|
| **Carcinogenic** = producing or tending to produce cancer<br>• Some agents, such as certain chemicals or forms of radiation, are both mutagenic and clastogenic.<br>• Genetic mutations and/or chromosomal damage can contribute to cancer formation. |
| **Clastogenic** = causing disruption of or breakages in chromosomes |
| **Genotoxic** = damaging to genetic material such as DNA and chromosomes |
| **Mutagenic** = inducing or capable of inducing genetic mutation |
| **Teratogenic** = interfering with fetal development and resulting in birth defects |

One drug has been approved in this new class of antiretroviral (ARV) drugs aimed at inhibiting integrase, the viral enzyme that catalyzes the two-step process of insertion of HIV DNA into the genome of the host cell. Integrase catalyzes a preparatory step that excises two nucleotides from one strand at both ends of the HIV DNA and a final "strand transfer" step that inserts the viral DNA into the exposed regions of cellular DNA. The integrase inhibitor drug class targets this second step in the integration process. Integration is required for the stable maintenance of the viral genome as well as for efficient viral gene expression and replication. Integrase also affects retrotranscription and viral assembly. Host cells lack the integrase enzyme. Because HIV integrase represents a distinct therapeutic target, integrase inhibitors would be expected to maintain activity against HIV that is resistant to other classes of ARV drugs.

***Raltegravir (Isentress)*** is classified as Food and Drug Administration Pregnancy Category C.
**(Last updated July 31, 2012; last reviewed July 31, 2012)**

- Animal carcinogenicity studies
  Raltegravir was neither mutagenic nor clastogenic in a series of *in vitro* and animal *in vivo* screening tests. Long-term animal carcinogenicity studies of raltegravir are ongoing.

- Reproduction/fertility animal studies
  Raltegravir produced no adverse effects on fertility of male or female rats at doses up to 600 mg/kg/day (providing exposures 3-fold higher than the exposure at the recommended adult human dose).

- Teratogenicity/developmental toxicity animal studies
  Studies in rats and rabbits revealed no evidence of treatment-related effects on embryonic/fetal survival or fetal weights from raltegravir administered in doses producing systemic exposures approximately 3- to 4-fold higher than the exposure at the recommended adult human daily dose. In rabbits, no treatment-related external, visceral, or skeletal changes were observed. However, treatment-related increases in the incidence of supernumerary ribs were seen in rats given raltegravir at 600 mg/kg/day (providing exposures 3-fold higher than the exposure at the recommended human daily dose).

- Placental and breast milk passage
  Placental transfer of raltegravir was demonstrated in both rats and rabbits. In rats given a maternal dose of 600 mg/kg/day, mean fetal blood concentrations were approximately 1.5- to 2.5-fold higher than in maternal plasma at 1 and 24 hours post-dose, respectively. However, in rabbits, the mean drug concentrations in fetal plasma were approximately 2% of the mean maternal plasma concentration at

both 1 and 24 hours following a maternal dose of 1000 mg/kg/day. In humans, raltegravir appears to readily cross the placenta. In P1026s, maternal and cord blood from six deliveries of mothers receiving raltegravir-based therapy during pregnancy were evaluated; the ratio of cord blood to maternal plasma was 0.98 (95% confidence interval, 0.09–2.26).[1] Other case reports have shown similarly high cord blood/maternal blood drug level ratios of 1.00 to 1.06.[2, 3] In a report of three pregnant women with multiresistant HIV-1 who were given raltegravir in late pregnancy to rapidly reduce maternal viral load, raltegravir concentrations within 3 hours of delivery in the neonates of two patients were approximately 7 and 9.5 times higher than in the mother's paired sample; in the third infant, maternal plasma was not available but neonatal concentration was still high 2.5 hours after delivery.[4] However, no adverse reactions were observed in mothers or infants. Raltegravir is secreted in the milk of lactating rats, with mean drug concentrations in milk about 3-fold higher than in maternal plasma at a maternal dose of 600 mg/kg/day. No effects in rat offspring were attributable to raltegravir exposure through breast milk. Whether raltegravir is secreted in human milk is unknown.

- Human studies in pregnancy
  Only limited data exist on the use of raltegravir in pregnancy. Raltegravir pharmacokinetics (PKs) were evaluated in 10 women in the IMPAACT P1026s study. Raltegravir PKs showed extensive variability but did not appear to be consistently altered during the third trimester compared with postpartum and historical data in non-pregnant individuals; thus the standard dose appears appropriate in pregnancy.[1] In a case series of 5 pregnant women treated with raltegravir in combination with 2 or 3 other ARV drugs because of persistent viremia or late presentation, the drug was well tolerated and led to rapid reduction in HIV RNA levels.[5] Drug levels were not measured in that study.

## References


1. Best BM, Capparelli EV, Stek A, et al. Raltegravir pharmacokinetics during pregnancy. Paper presented at: 50th Interscience Conference on Antimicrobial Agents and Chemotherapy (ICAAC); September 12-15, 2010; Boston, MA.
2. Pinnetti C, Baroncelli S, Villani P, et al. Rapid HIV-RNA decline following addition of raltegravir and tenofovir to ongoing highly active antiretroviral therapy in a woman presenting with high-level HIV viraemia at week 38 of pregnancy. *J Antimicrob Chemother*. Sep 2010;65(9):2050-2052. Available at http://www.ncbi.nlm.nih.gov/pubmed/20630894.
3. Croci L, Trezzi M, Allegri MP, et al. Pharmacokinetic and safety of raltegravir in pregnancy. *Eur J Clin Pharmacol*. Mar 1 2012. Available at http://www.ncbi.nlm.nih.gov/pubmed/22382989.
4. McKeown DA, Rosenvinge M, Donaghy S, et al. High neonatal concentrations of raltegravir following transplacental transfer in HIV-1 positive pregnant women. *AIDS*. Sep 24 2010;24(15):2416-2418. Available at http://www.ncbi.nlm.nih.gov/pubmed/20827058.
5. Taylor N, Touzeau V, Geit M, et al. Raltegravir in pregnancy: a case series presentation. *Int J STD AIDS*. Jun 2011;22(6):358-360. Available at http://www.ncbi.nlm.nih.gov/pubmed/21680678.

## Antiretroviral Pregnancy Registry (Last updated September 14, 2011; last reviewed July 31, 2012)

The Antiretroviral Pregnancy Registry is an epidemiologic project to collect observational, nonexperimental data on antiretroviral (ARV) drug exposure during pregnancy for the purpose of assessing the potential teratogenicity of these drugs. Registry data will be used to supplement animal toxicology studies and assist clinicians in weighing the potential risks and benefits of treatment for individual patients. The registry is a collaborative project of the pharmaceutical manufacturers with an advisory committee of obstetric and pediatric practitioners.

It is strongly recommended that health care providers who are treating HIV-infected pregnant women and their newborns report cases of prenatal exposure to ARV drugs (either alone or in combination) to the Antiretroviral Pregnancy Registry. The registry does not use patient names, and birth outcome follow-up is obtained from the reporting physician by registry staff.

**Referrals should be directed to:**

**Antiretroviral Pregnancy Registry**
**Research Park**
**1011 Ashes Drive**
**Wilmington, NC 28405**
**Telephone: 1–800–258–4263**
**Fax: 1–800–800–1052**
**http://www.APRegistry.com**

# Appendix B: Acronyms

| | |
|---|---|
| 3TC | lamivudine |
| ABC | abacavir |
| ACOG | American College of Obstetricians and Gynecologists |
| ALT | alanine aminotransferase |
| anti-HBc | hepatitis B core antibody |
| anti-HBs | hepatitis B surface antibody |
| AOR | adjusted odds ratio |
| AP | antepartum |
| ART | antiretroviral therapy |
| ARV | antiretroviral |
| AST | aspartate aminotransferase |
| ATV | atazanavir |
| ATV/r | atazanavir/ritonavir |
| AUC | area under the curve |
| AZT | zidovudine |
| BID | twice daily |
| BMI | body mass index |
| CBC | complete blood count |
| CDC | Centers for Disease Control and Prevention |
| CI | confidence interval |
| $C_{max}$ | maximum plasma concentration |
| $C_{min}$ | minimum plasma concentration |
| CNS | central nervous system |
| CVS | chorionic villus sampling |
| CYP | cytochrome P |
| CYP3A4 | cytochrome P450 3A4 |
| d4T | stavudine |
| ddI | didanosine |
| DMPA | depot medroxyprogesterone acetate |
| DRV | darunavir |
| DRV/r | darunavir/ritonavir |
| DSMB | Data and Safety Monitoring Board |
| EC | enteric coated |
| ECG | electrocardiogram |
| EFV | efavirenz |
| EMS | ethyl methane sulfonate |
| ETR | etravirine |
| FDA | Food and Drug Administration |
| FPV | fosamprenavir |
| FPV/r | fosamprenavir/ritonavir |
| FTC | emtricitabine |

| | |
|---|---|
| gp | glycoprotein |
| HAV | hepatitis A virus |
| HBIG | hepatitis B immune globulin |
| HBsAg | hepatitis B surface antigen |
| HBV | hepatitis B virus |
| HCV | hepatitis C virus |
| HELLP | hemolysis, elevated liver enzymes, and low platelets |
| HGC | hard gel capsule |
| HR | hazard ratio |
| HRSA | Health Resources and Services Administration |
| $IC_{50}$ | inhibitory concentration 50% |
| IDV | indinavir |
| IGF | insulin-like growth factor |
| IP | intrapartum |
| IQR | interquartile range |
| IRIS | immune reconstitution inflammatory syndrome |
| IUD | intrauterine device |
| IV | intravenous/intravenously |
| LPV/r | lopinavir/ritonavir |
| MAC | *Mycobacterium avium* complex |
| MACDP | Metropolitan Atlanta Congenital Defects Program |
| MIRIAD | Mother-Infant Rapid Intervention at Delivery (study) |
| MTCT | mother-to-child transmission |
| mtDNA | mitochondrial DNA |
| MVC | maraviroc |
| NFV | nelfinavir |
| NIH | National Institutes of Health |
| NNRTI | non-nucleoside reverse transcriptase inhibitor/non-nucleoside analogue reverse transcriptase inhibitor |
| NRTI | nucleoside reverse transcriptase inhibitor/nucleoside analogue reverse transcriptase inhibitor |
| NtRTI | nucleotide analogue reverse transcriptase inhibitor |
| NVP | nevirapine |
| OC | oral contraceptive |
| OI | opportunistic infection |
| OR | odds ratio |
| PACTG | Pediatric AIDS Clinical Trials Group |
| PCP | *Pneumocystis jirovecii* pneumonia |
| PCR | polymerase chain reaction |
| PI | protease inhibitor |
| PK | pharmacokinetic |
| PMTCT | prevention of mother-to-child transmission |
| PP | postpartum |
| PPI | proton pump inhibitor |

| | |
|---|---|
| PrEP | pre-exposure prophylaxis |
| PTD | preterm delivery |
| RAL | raltegravir |
| RDS | respiratory distress syndrome |
| RPV | rilpivirine |
| RR | relative risk |
| RTV | ritonavir |
| sd | single dose |
| SQ | subcutaneous |
| SQV | saquinavir |
| SQV/r | saquinavir/ritonavir |
| STD | sexually transmitted disease |
| T20 | enfuvirtide |
| TDF | tenofovir disoproxil fumarate |
| TDM | therapeutic drug monitoring |
| TID | three times daily |
| TPV | tipranavir |
| TPV/r | tipranavir/ritonavir |
| UGT | uridine diphosphate glucuronosyltransferase |
| WHO | World Health Organization |
| WITS | Women and Infants Transmission Study |
| ZDV | zidovudine |