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6. HAZARDOUS WASTE DISPOSAL

Hospitals generate large amounts of diverse wastes that require disposal. Much of the waste is hazardous and must therefore be packaged, transferred, and disposed of properly to protect both the persons handling it and the environment.

Hospital wastes can be categorized as infectious or noninfectious. Infectious wastes include human, animal, or biological wastes and any items that may be contaminated with pathogens. Noninfectious wastes include toxic chemicals, cytotoxic drugs, and radioactive, flammable, and explosive wastes.

6.1 INFECTIOUS WASTES

The material in this section is extracted from the EPA Guide for Infectious Waste Management (EPA 1986). The following publications are also recommended:

- Guideline for Handwashing and Hospital Environmental Control, Section 4 (Garner and Favero 1985). This document is reprinted in Appendix 8.
- Guideline for Isolation Precautions in Hospitals (Garner and Simmons 1983). This document is reprinted in Appendix 8.
- Waste Disposal in Microbiology Laboratories, Chapter 9 (Mackel and Mallison 1981).

6.1.1 Infectious Waste Management Plan

Compliance with State and local regulations should be carefully considered when developing an infectious waste treatment plan. Each hospital should develop an infectious waste management plan that provides for (1) designation of the waste that should be managed as infectious, (2) segregation of infectious waste from the noninfectious waste, (3) packaging, (4) storage, (5) treatment, (6) disposal, (7) contingency measures for emergency situations, and (8) staff training.

6.1.2 Types of Infectious Waste

Infectious wastes may be classified as isolation wastes, cultures and stocks of infectious agents and associated biologicals, human blood and blood products, pathological wastes, contaminated sharps, contaminated carcasses, body parts, and bedding, or miscellaneous contaminated wastes. Each of these categories is discussed briefly as follows:

- **Isolation wastes** are those generated by patients who are isolated because of communicable diseases.

- **Cultures and stocks of infectious agents and associated biologicals** include specimen cultures from medical and pathological laboratories, cultures and stocks of infectious agents from research and industrial laboratories, wastes from the production of biologicals, discarded live and attenuated vaccines, and culture dishes and devices used to transfer, inoculate, and mix cultures.

- **Human blood and blood products** include blood as well as serum, plasma, and other blood products.

- **Pathological wastes** include tissues, organs, body parts, and body fluids that are removed during surgery and autopsy.

- **Contaminated sharps** are hypodermic needles, syringes, Pasteur pipettes, broken glass, and scalpel blades. These items should be considered infectious wastes because of the possibility of contamination with blood-borne pathogens.

- **Contaminated carcasses, body parts, and bedding** emanate from animals intentionally exposed to pathogens during research, the production of biologicals, or the <u>in vivo</u> testing of pharmaceuticals.

- **Miscellaneous wastes** that are not designated as infectious should be assumed to be infectious and should be managed as such to maintan consistent levels of protection for both the environment and for persons handling these wastes. Miscellaneous wastes include those from surgery and autopsies, contaminated laboratory wastes, dialysis unit wastes, and contaminated equipment.

  -- **Wastes from surgery and autopsies** include soiled dressings, sponges, drapes, lavage tubes, drainage sets, underpads, and surgical gloves.

  -- **Contaminated laboratory wastes** include specimen containers, slides and cover slips, disposable gloves, laboratory coats, and aprons.

-- **Dialysis unit wastes** include contaminated disposable equipment and supplies such as tubing, filters, disposable sheets, towels, gloves, aprons, and laboratory coats.

-- **Contaminated equipment** refers to discarded equipment and parts that are used in patient care, medical and industrial laboratories, research, and the production and testing of certain pharmaceuticals.

6.1.3 Treatment and Disposal Methods

Several methods are used for infectious waste treatment, depending on the type of waste material. These treatment methods include steam sterilization, incineration, thermal inactivation, gas/vapor sterilization, chemical disinfection, and sterilization by irradiation. After treatment, the wastes or their ashes can be disposed of by discharge into sanitary sewer systems (for liquid or ground-up waste) or burial in sanitary landfills. Acceptable treatment methods for the various types of wastes are listed in Table 6-1.

6.1.3.1 Steam Sterilization (Autoclaving)

Steam sterilization (autoclaving) involves the use of saturated steam within a pressure vessel at temperatures high enough to kill infectious agents in the waste. Sterilization is accomplished primarily by steam penetration. Steam sterilization is most effective with low-density material such as plastics. An alternative treatment method (e.g., incineration) should be used on high-density wastes such as large body parts or large quantities of animal bedding or fluids because they inhibit direct steam penetration and require longer sterilization times.

Containers that can be used effectively in steam sterilization are plastic bags, metal pans, bottles, and flasks. High-density polyethylene and polypropylene plastic should not be used in this process because they do not facilitate steam penetration to the waste load. Heat-labile plastic bags allow steam penetration of the waste, but they may crumble and melt. If heat-labile plastic bags are used, they should be placed in another heat-stable container that allows steam penetration (such as a strong paper bag), or they should be treated with gas/vapor sterilization.

The following precautions should be taken when using steam sterilization:

- Plastic bags should be placed in a rigid container before steam treatment to prevent spillage and drain clogging.

Table 6-1. Recommended techniques for treatment of infectious wastes*

Type of infectious waste	Recommended treatment techniques†				
	Steam sterilization	Incineration	Thermal inactivation	Chemical disinfection§	Other
Isolation wastes	X	X			
Cultures and stocks of infectious agents and associated biologicals	X	X	X	X	
Human blood and blood products	X	X		X	X**
Pathological wastes	X††	X			X§§
Contaminated sharps	X	X			
Contaminated animal wastes:					
Carcasses and parts	X††	X			
Bedding		X			

* Taken from EPA (1986).

† The recommended treatment techniques are those that are most appropriate and are generally in common use; an alternative treatment technique may be used to treat infectious waste if it provides effective treatment.

§ Chemical disinfection is most appropriate for liquids.

** Discharge to the sanitary sewer for treatment in the municipal sewage system (provided that secondary treatment is available.

†† For aesthetic reasons, steam sterilization should be followed by incineration of the treated waste or by grinding with subsequent flushing to the sewer system in accordance with State and local regulations.

§§ Handling by a mortician (burial or cremation).

- To facilitate steam penetration, bags should be opened and caps and stoppers should be loosened immediately before they are placed in the steam sterilizer.

- Care should be taken to separate infectious wastes from other hazardous wastes.

The following precautions should be taken when using steam sterilization:

- Plastic bags should be placed in a rigid container before steam treatment to prevent spillage and drain clogging.

- To facilitate steam penetration, bags should be opened and caps and stoppers should be loosened immediately before they are placed in the steam sterilizer.

- Care should be taken to separate infectious wastes from other hazardous wastes.

- Infectious waste that contains noninfectious hazards (see Section 5) should not be steam-sterilized because of the possibility that the equipment operator will be exposed to toxic, radioactive, or other hazardous chemicals.

- Waste that contains antineoplastic drugs, toxic chemicals, or chemicals that would be volatilized by steam should not be steam-sterilized.

- Persons involved in steam sterilizing should be trained in handling techniques to minimize personal exposure to hazards from these wastes. Some of these techniques include:

  -- Use of protective equipment

  -- Minimization of aerosol formation

  -- Prevention of waste spillage during autoclave loading and unloading

  -- Prevention of burns from handling hot containers

  -- Management of spills

- The autoclave temperature should be checked with a recording thermometer to ensure that the proper temperature is being maintained for a long enough period during the cycle.

- Steam sterilizers should be routinely inspected and serviced, and the process should be routinely monitored to ensure that the equipment is functioning properly.

6.1.3.2 Incineration

Incineration converts combustible materials into noncombustible residue or ash. Gases are ventilated through the incinerator stacks, and the residue or ash is disposed of in a sanitary landfill. If incinerators are properly designed, maintained, and operated, they are effective in killing organisms present in infectious waste. Although all types of infectious waste can be disposed of by incineration, the process is especially useful for aesthetic disposal of pathological wastes such as tissues and body parts. Incineration also renders contaminated sharps unusable. The principal factors to consider when incinerating infectious wastes are variations in waste composition, the waste feed rate, and the combustion temperature. Infectious wastes containing antineoplastic drugs should be disposed of in an incinerator that provides high temperatures and enough time for the complete destruction of these compounds. The incinerator's effectiveness in disposing of chemical wastes should be documented before such use.

6.1.3.3 Thermal Inactivation

Thermal inactivation involves the treatment of waste with high temperatures to eliminate the presence of infectious agents. This method is usually used for large volumes of infectious waste. Liquid waste is collected in a vessel and heated by heat exchangers or a steam jacket surrounding the vessel. The types of pathogens in the waste determine the temperature and duration of treatment. After treatment, the contents can be discharged into the sewer in a manner that complies with State, Federal, and local requirements. Solid infectious waste is treated with dry heat in an oven, which is usually electric. This method requires higher temperatures and longer treatment cycles than steam treatment.

6.1.3.4 Gas/Vapor Sterilization

Gas/vapor sterilization uses gaseous or vaporized chemicals as the sterilizing agents. Ethylene oxide is the most commonly used agent, but should be used with caution since it is a suspected human carcinogen (see Section 5 for a discussion of ethylene oxide toxicity and work practices). Because ethylene oxide may be adsorbed on the surface of treated materials, the potential exist for worker exposure when sterilized materials are handled.

6.1.3.5 Chemical Disinfection

Chemical disinfection is the preferred treatment for liquid infectious wastes, but it can also be used in treating solid infectious waste. The following factors should be considered when using chemical disinfection:

- Type of microorganism
- Degree of contamination
- Amount of proteinaceous material present
- Type of disinfectant
- Contact time
- Other relevant factors such as temperature, pH, mixing requirements, and the biology of the microorganism

Ultimate disposal of chemically treated waste should be in accordance with State and local requirements.

6.1.3.6 Sterilization by Irradiation

Sterilization by irradiation is an emerging technology that uses ionizing radiation. Advantages over other treatment methods are as follows:

- Electricity requirements are nominal.
- Steam is not required.
- No heat or chemicals remain in the treated waste.

The principal disadvantages are as follows:

- Capital costs are high.
- Highly trained operating and support personnel are required.
- Space requirements are great.
- The potential exists for worker exposure as a result of leaks in seals or poor work practices.
- Ultimate disposal of the radiation source may pose problems.

6.1.4 Separation of Infectious and Noninfectious Wastes

Infectious and noninfectious wastes should be separated at the point of generation. If the infectious waste contains noninfectious hazards, it should be identified and subjected to additional treatment.

Infectious waste should be discarded into clearly identifiable containers or plastic bags that are leakproof and puncture-resistant. Red or orange bags are usually used for infectious waste. The containers should also be marked with the universal symbol for biological hazards (see Figure 6-1).

6.1.5 Packaging

Infectious wastes should be contained from the point of origin to the point at which they are no longer infectious. The packaging should be appropriate for the type of waste involved, and it must endure handling, storage, transportation, and treatment.

Liquid infectious wastes can be placed in capped or tightly stoppered bottles or flasks. Large quantities may be placed in containment tanks.

Solid or semisolid wastes may be placed in plastic bags, but the following recommendations should be heeded:

- Select tear-resistant plastic bags. Plastic bags are judged by their thickness or durability as evaluated by the ASTM dart test (ASTM 1975). Use one or both of these criteria in the procurement process. The most important consideration is tear-resistance.
- Do not place sharps, sharp items, or items with sharp corners in the bags. (Place sharps in impervious, rigid, puncture-resistant containers made of glass, metal, rigid plastic, or wood.)
- Do not load a bag beyond its weight or volume capacity.
- Keep bags from coming into contact with sharp external objects.
- Consider double bagging.

Some treatment techniques require special packaging characteristics. For example, incineration requires combustible containers, and steam sterilization requires packaging materials such as low-density plastics that allow steam penetration and evacuation of air.

6.1.6 Handling and Transportation

When the waste is to be moved about for treatment or storage, special handling or packaging may be necessary to keep bags intact and to ensure containment of the waste. The following procedures are recommended:

Figure 6-1. Universal symbol for biological hazards. The symbol is fluorescent orange or orange-red. The background may be any color that provides sufficient contrast for the symbol to be clearly defined.

- Single-bagged waste and containers of sharps and liquids should be placed within a rigid or semirigid container such as a bucket, box, or carton lined with plastic bags.

- Containers should be covered with lids during transportation and storage.

- When handling or transporting plastic bags of infectious waste, care should be taken to prevent tearing the bags. Instead of chutes or dumbwaiters, carts should be used for transporting bags of infectious waste within the facility.

- Carts and recyclable containers that are used repeatedly for transport and treatment of bagged waste should be disinfected after each use. Single-use containers should be destroyed as part of the treatment process.

- Infectious waste should not be compacted before treatment. This process could damage the packaging and disperse the contents, or it could interfere with the effectiveness of treatment.

- Outside the hospital, infectious waste should be transported in closed, leakproof dumpsters or trucks.

- The waste should be placed in rigid or semirigid, leakproof containers before being loaded onto trucks.

6.1.7 Storage

- Infectious waste should be stored for a minimum amount of time and should be packaged securely enough to ensure containment of the waste and to prevent penetration by rodents and vermin.

- Limited access to the storage area is recommended.

- The universal biological hazard symbol (Figure 6-1) should be posted on the storage area door, waste containers, freezers, or refrigerators.

- Containers for biohazardous material should be a distinctive red or orange color.

6.1.8 Contingency Measures

Contingency measures should be developed to deal with emergencies that occur during the handling, transportation, or disposal of infectious waste. Emergencies include spills of liquid infectious waste, ruptures of plastic bags or other containers holding infectious waste, and equipment failure.

6.1.9 Ultimate Disposal

For ultimate disposal of treated infectious waste, EPA recommends contacting State and local governments to identify approved disposal options. EPA also recommends (1) the discharge of treated liquids and ground solids (e.g., pathological wastes or small animals) to the sewer system, and (2) landfill disposal of treated solids and incinerator ash. Landfilling of infectious wastes is allowed in some States and prohibited in others. EPA recommends that only treated infectious wastes be buried in landfills. They further recommend that facilities secure the services of reputable waste handlers to ensure (to the extent possible) that ultimate disposal of hazardous wastes is performed according to applicable Federal, State, and local regulations.

6.1.10 Training

All workers who handle infectious waste should receive infectious waste management training that includes (1) explanation of the infectious waste management plan, and (2) assignment of roles and responsibilities for implementation of the plan. Refresher courses should also be given periodically.

6.2 NONINFECTIOUS WASTES

6.2.1 Chemical Wastes

Chemical wastes include toxic chemicals, cytotoxic drugs, radioactive materials, and flammable and explosive wastes. These wastes should be classified at the time of collection to avoid mixing chemicals that are incompatible (NFPA 1983). Disposal of chemical wastes should be handled in accordance with good safety practices and applicable government regulations. Persons or agencies involved with the removal of these wastes should be informed of their characteristics and hazards.

6.2.2 Cytotoxic Wastes

OSHA has issued work practice guidelines for workers who deal with cytotoxic (antineoplastic) drugs (OSHA 1986). These guidelines are reproduced as Appendix 7 of this document. They address drug preparation, drug administration, waste disposal, spills, medical surveillance, storage and transport, training, and information dissemination.

6.2.3 Radioactive Wastes

Three classes of radioactive wastes may be found in hospitals: solids, liquids, and gases. This section summarizes the recommendations of the National Council on Radiation Protection and Measurements (NCRP 1976).

Solid radioactive wastes may include rags or papers from cleanup operations, solid chemicals, contaminated equipment, experimental animal carcasses, and human or experimental animal fecal material. Human and animal fecal material may generally be disposed of through the sanitary sewer system (NCRP 1976). For other solid wastes, disposal depends on the half-life of the radionuclide. For those nuclides with short half-lives, the solid material may be stored in a secure place until decay has occurred. Solid waste contaminated by nuclides with long half-lives should be disposed of by a licensed commercial disposal company. Contaminated equipment should be cleaned with large amounts of water, which should be disposed of as radioactive liquid waste.

Radioactive urine may generally be disposed of immediately through the sanitary sewer system, but the toilet should be flushed several times after each use (Stoner et al. 1982). In cases in which the patient has received a large dose of radioactive iodine, urine is generally collected for the first 48 hr after administration, taken to the laboratory for analysis, and flushed down the sanitary sewer system with large quantities of water. Other liquid wastes can be handled in the same manner as solid wastes. Those with short half-lives can be stored in a sealed container until the radioactivity decays; those with long half-lives should be disposed of by a licensed disposal company.

Gaseous radioactive wastes should be vented to the outside of the hospital so that recirculation of the exhaust air does not occur.

6.2.4 Flammable Wastes

Refer to Sections 3.1.3 and 3.1.4 for discussion of flammable and explosive wastes.

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