



Embedded Metal Fragments: a Cause for Concern?

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Summary

- Background
- Depleted Uranium
 - DU Screening of Deployed Service Members
 - DU Capstone Study
 - VA DU Medical Follow-up Program
- Tungsten Alloys Concerns
- Embedded Metal Fragments Workshop
- Future Plans, Programs, Policies



Depleted Uranium

- Specific Gravity – 19 g/cm^3 (2.42 X Fe)
- Melting Point – $1,132^\circ \text{ C}$
- The most effective armor plate penetrator
- Self sharpening
- Scatters into smaller-sized particles when compared to lead and tungsten
- 16 munition items in inventory



DU



Isotopic Comparison of Natural and Depleted Uranium

Isotope	<u>Radioactivity</u> μCi/g	<u>Natural Uranium</u> Concentration of isotopes	<u>Depleted Uranium</u> Concentration of isotopes
^{234}U	6200.0	0.0058%	0.001%
^{235}U	2.2	0.72%	0.2%
^{238}U	0.3	99.28%	99.8%
Relative Radioactivity		100%	60%



Depleted Uranium Background

- 1991 Gulf War involved first widespread combat use of depleted uranium (DU) munitions
- Some Service members were injured by DU munitions in combat
- Metal fragments were left in place if risk of surgery was greater than risk of leaving fragments—assumed fragments were not toxic
- Uncertainty about long-term DU health effects promoted the search for substitutes for DU in munitions—led to use of tungsten alloys



Depleted Uranium Screening

- ASD(HA) Policy 03-12, “Policy for the Operation Iraqi Freedom Depleted Uranium (DU) Medical Management”
May 30, 2003
 - Level I and II exposures – requirement to screen for DU in individuals with higher risk of exposure
 - Level III exposures- any person concerned about exposure may obtain an evaluation and bioassay if desired
- Post-deployment health assessments ask about DU exposure
- Servicemembers who report DU exposure complete an additional DU questionnaire and can request a DU test



DU Exposure Categories



I *	Soldiers in, on, or near armored vehicle struck and penetrated with DU munitions
II *	Soldiers whose military occupation requires entering DU-damaged vehicles
III **	Soldiers with incidental DU exposure

*Bioassay Mandatory

**Bioassay Optional



DU Bioassay Results – Cumulative Totals

June 1, 2003 – March 31, 2006

	Army	Navy/ Marine	Air Force	Totals	Elevated Total Uranium	Detectable Levels of DU in Urine	Retained Fragments or Fragment- Type Injury
Level I	197	48	2	247	4	6	17
Level II	298	220	8	526	0	0	1
Level III	214	43	7	264	0	0	7
Uncat	1126	11	0	1137	0	1	29
Totals	1835	322	17	2174	4	7	54

Veterans Affairs DU Follow-up Program

- Program began in 1993 for the 1991 Gulf War veterans
- Service members with the highest risk of DU exposures were invited to participate
- Of the 104 with retained depleted uranium fragments or inhalational exposures, 74 have participated
- Four of the eight OIF veterans with detectable levels of DU also joined the cohort study
- Veterans with inhalational exposure rapidly cleared the DU and appear to have had no adverse effects
- Veterans with retained DU fragments continue to excrete elevated levels of urinary uranium
- None have developed kidney abnormalities, leukemia, bone, lung cancer, or any other uranium/radiation related health problem



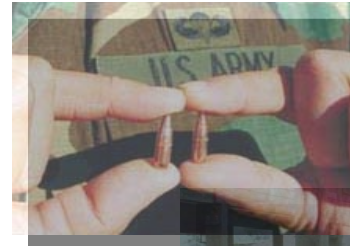
DU Capstone Study

- Description: 4-year, \$6.4 million study published in 2004
- Method: 13 DU rounds fired at Abrams tanks and Bradley Fighting Vehicles
- Analysis: 8,000 samples taken within vehicles – aerosols characterized
- Results:
 - Predicted radiation doses are below U.S. peacetime safety standards and not likely to cause adverse health effects
 - Predicted uranium concentrations in the kidneys are not likely to cause adverse health effects



Tungsten

- Specific Gravity – 19.25 g/cm³ (2.45 X Fe)
- Melting Point - 3422° C
- Tungsten is used in various munitions;
 - 470 unique US munitions
 - Small arms to bunker busters
- Typically alloyed with cobalt, nickel, tin, copper, and/or iron
- Used by many countries



Tungsten Alloys

- Developed as an alternative to DU in munitions because of concerns about environmental impact of DU
- Currently concerned about development of aggressive rhabdomyosarcoma in rats implanted with W/Ni/Co alloy
- ASD(HA) requested USD(AT&L) Director of Defense Systems to fund “with the highest priority possible” tungsten alloy munitions research relating to the long-term risks associated with embedded fragments
- USD(AT&L) memo to munitions developers required “deliberate action to ensure that appropriate health-hazard assessments are included in human systems integration plans for tungsten/alloy munitions...”



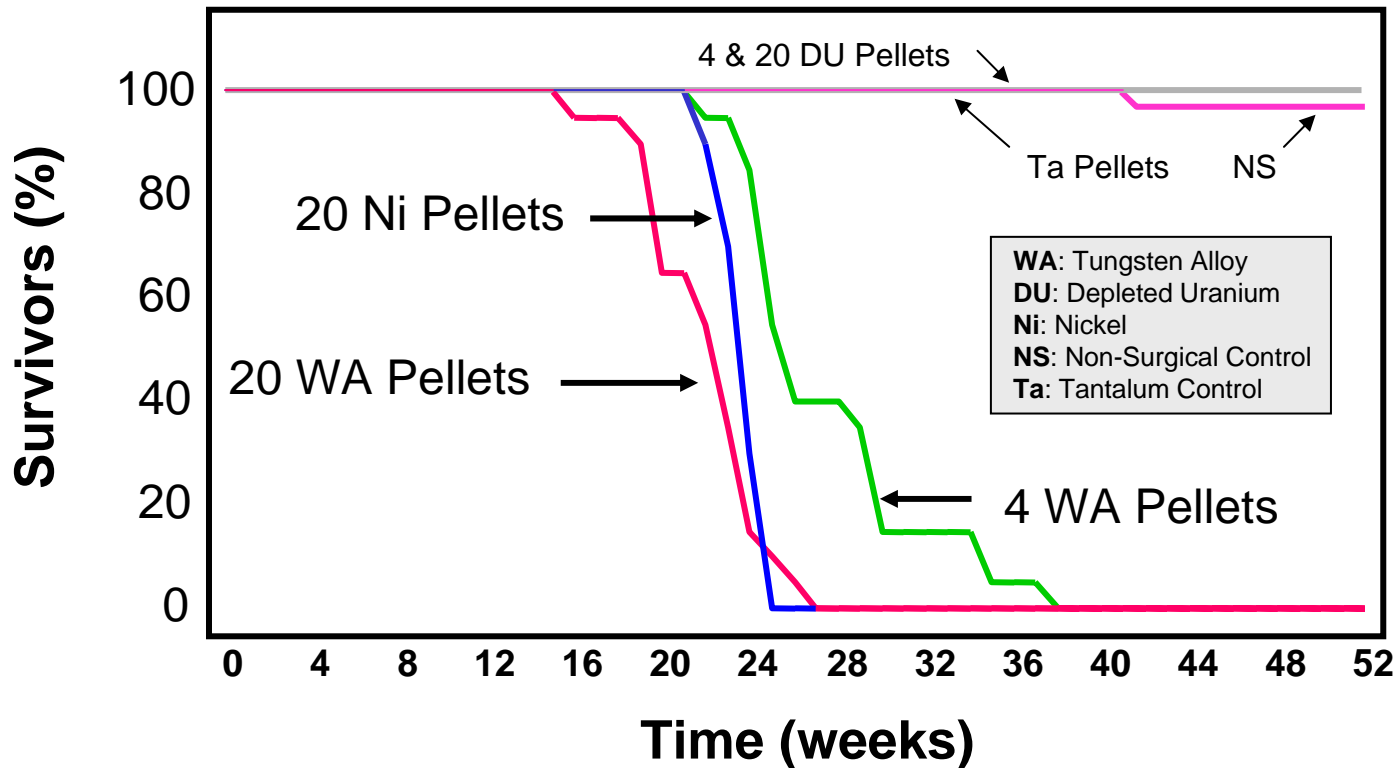
AFRRI Embedded Heavy Metals Health Effects Research

- Implanted metal pellets in Fisher 344 rats
 - Depleted uranium (DU)
 - 92% Tungsten/5% Nickel/3% Cobalt Alloy (W/Ni/Co)
 - Nickel (Ni)
 - Tantalum (Ta)
- Followed for up to 24 months
- All DU and Ta implanted rats survived
- All Ni and W/Ni/Co alloy rats died



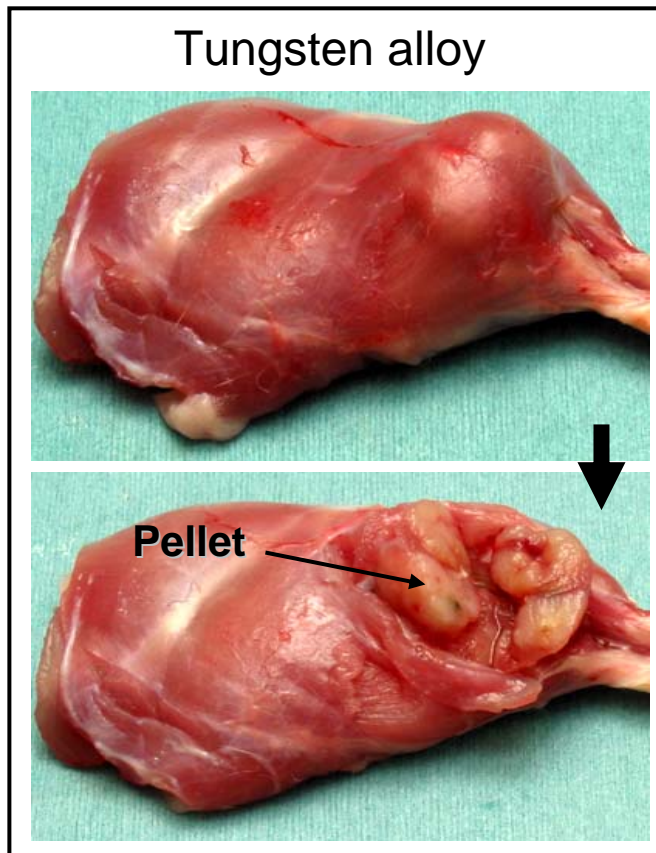


Survival After Pellet Implantation





Tungsten Alloy-Associated Tumors

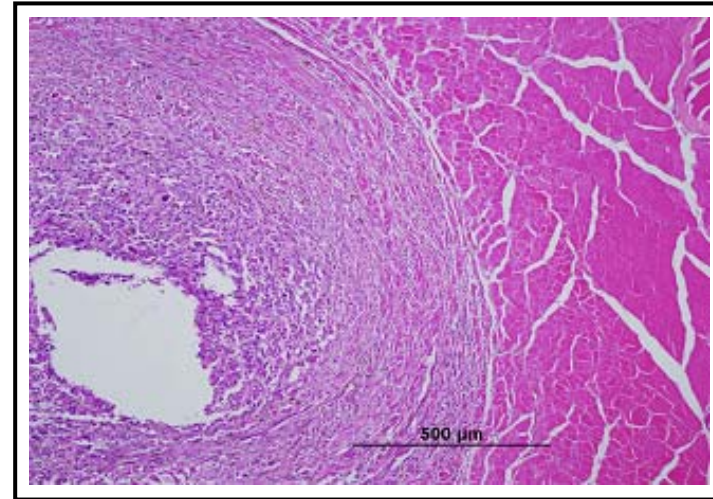


- Rapidly growing tumors up to 5 cm in diameter
- No tumors in Ta controls





Tumor Characterization



- Pleomorphic rhabdomyosarcoma
- Tumor displaces and replaces skeletal muscle around pellet
- Pulmonary Metastases



USACHPPM Embedded Heavy Metals Health Effects Research

- Implanted metal pellets in Fisher 344 rats
 - Tungsten (W)
 - 92% Tungsten/5% Nickel/3% Cobalt Alloy (W/Ni/Co)
 - 97% Tungsten/2% Nickel/1% Iron Alloy (W/Ni/Fe)
 - Tantalum (Ta)
- Currently 12 months into study, plan to follow for up to 24 months
- All W, W/Ni/Fe, Ta implanted rats are alive
- All W/Ni/Co rats developed tumors—rhabdomyosarcoma
- Confirmed AFRII study



USACHPPM Metal Fragment Analysis

- 58 fragments from 50 individuals have been analyzed for their metal composition
- No fragments with tungsten identified to date



Embedded Metal Fragments Workshop

- Jan 17-18, 2006, workshop sponsored by the Deputy Assistant to the Secretary of Defense for Force Health Protection and Readiness
- Disciplines represented: surgery, occupational medicine, toxicology, pathology, radiology, metallurgy, public health, preventive medicine
- Other organizations represented: All Services, VA, ASD(HA), AFIP, USACHPPM, Deployment Health Clinical Center, US Army Heavy Metals Office



Embedded Metal Fragments Workshop

Consensus Statements

- Some metals used in weapons are potentially harmful as retained metal fragments by virtue of their toxicity
- Current policies/procedures are inadequate for assessing and managing casualties with all types of retained metal fragments
- There should be a registry of all Service members with retained metal fragments
- All metal fragments that are removed from Service members should be sent for analysis



Embedded Metal Fragments Workshop

Questions to be Addressed

- Are W/Ni/Co tungsten alloy embedded fragments carcinogenic in humans?
- Are all tungsten alloys equally hazardous in humans?
- Are tungsten alloys currently used on the battlefield?
- Are there Service members today with embedded tungsten alloy fragments?
- Can a biologic test determine the nature of an unknown embedded fragment?



Future Plans, Programs, Policy

- Working with the Joint Theater Trauma Registry to identify service members with retained metal fragments
- Investigating the incidence of rhabdomyosarcoma in active duty and recently retired service members
- Working with the IED task force, AFMIC, and DIA to determine extent of tungsten use in OEF/OIF
- Preparing policy to require all fragments removed from service members are sent for analysis



Requirements/Drivers/Issues

- Need for additional study on tungsten alloy
 - Health effects of different alloys
 - Health effects of W/Ni/Co alloy on different species
 - Biomarkers for W/Ni/Co alloy
- Retrospective analysis of Rhabdomyosarcoma in active duty and retired Service members





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