Radiological Terrorism Fact Sheet

Radiological Weapons - "Dirty" Bombs

Gamma Emitters: Cobalt and Cesium

Gamma rays are uncharged radiation similar to x-rays. They are high-energy particles that easily pass through matter. With such high penetrability, the primary toxicity of gamma radiation is whole-body exposure.

Exposing non-radioactive cobalt to intense radiation in the reactor core of a commercial nuclear reactor makes **cobalt-60**. It generates high-energy gamma rays and beta rays. **Cobalt-60** has a half-life of 5 years. Since cobalt is a solid metal, should a containment canister break, it will not spread through the environment. Cobalt will be rapidly absorbed from the lung, but less than 5% will be absorbed from the GI tract. Nothing is known about absorption from wounds.

Cesium-137 is a by-product of the manufacture of weapons-grade radioactive substances and has a half-life of 31 years. In contrast to metallic cobalt, cesium is a salt, which means it dissolves in water and poses an environmental threat should a storage canister break or leak. It emits both gamma and beta radiation; is completely absorbed by the lungs and GI tract, and from wounds; and is excreted in the urine.

Beta Emitters: Strontium and Phosphorus

Beta particles, found primarily in fallout radiation, are very light, charged particles that can travel a short distance in tissue. If large quantities are involved, they can damage the basal stratum of the skin causing a "beta burn" that is similar to a thermal burn. Their main threat comes from being internalized through inhalation or ingestion.

Strontium-90 is a direct fission product of uranium. It and its daughters emit both beta and gamma rays, although beta irradiation is its primary external hazard if present in quantity. Strontium will follow calcium and is readily absorbed by both respiratory and GI routes. Up to 50% of a dose will be deposited in bone.

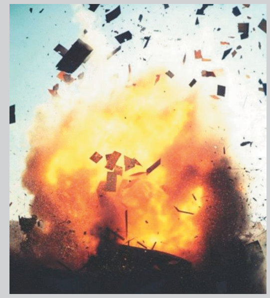
Phosphorus-32, found in research labs and medical facilities, is a strong beta emitter. Phosphorus is completely absorbed from all sites and is deposited in the bone marrow and other rapidly replicating cells. Local irradiation causes cell damage.

Alpha Emitters: Americium, Radium

Alpha particles are massive, charged particles that cannot travel far and are completely stopped by the dead layers of the skin or by clothing. Alpha particles offer minimal external hazard, but can cause significant regional cellular damage when internalized. The main threat from a RDD using an alpha emitter is from contaminated dust and other particles that would be inhaled or ingested.

Americium-241 is a decay daughter of plutonium and an alpha emitter. Its main threat is heavy metal poisoning, but, in large quantities, can cause whole-body irradiation. Seventy-five percent of the initial lung burden is absorbed, with 10% of the particles retained in the lung. Gastrointestinal absorption of americium is minimal, but it may be absorbed rapidly from skin wounds. It is eliminated by urinary and hepatic excretion.

Radium-226 is used for instrument illumination, in industrial applications, and in older medical equipment. Its primary radiation is alpha particles, but daughter products emit beta and gamma rays and, in quantity, may present a serious external irradiation hazard. The most common exposure is by ingestion, with 30% absorption. Little is known about wound absorption. Radium will follow calcium to bone deposition, so long-term exposure is associated with leukemia, aplastic anemia, and sarcomas.



Conventional explosion photo
Photo courtesy Department of Defense

Overview

A "dirty" bomb, or radiation dispersal device (RDD), is a conventional, explosive bomb to which radioactive material has been added. The blast of the weapon not only kills and injures directly, but also spreads the radioactive material to the surrounding area and via airborne spread. The size and sophistication of the bomb, the type of radioactive material used, and weather conditions dictate the extent of the contaminated area, while the speed of evacuation dictates the level of human exposure.

The real threat of a RDD is one of fear and disruption. The immediate casualties would be those of the initial blast, but panic over potential radiation exposure could cause additional victims and disrupt rescue and evacuation efforts. The area's remaining off-limits for several months of expensive clean up, possibly including building demolition and soil replacement, would cause further disruption.

The most likely radioactive materials to be used are cobalt-60, strontium-90, cesium-137 and americium-241, which are often poorly protected and readily available from military, medical, academic, research, and industrial sources. As an example, cobalt-60 is used in food irradiation, while americium is used in smoke detectors and oil exploration. These materials are already believed to be in the possession of major international terrorist groups. Military-grade plutonium and uranium would be more deadly, but are significantly harder to obtain, handle and safely transport. [For information on these two isotopes, as well as radioactive iodine, see the "Nuclear Blast Fact Sheet."]

Health Risks

Other than the trauma associated with being caught in the explosion itself, the primary health risk from a "dirty bomb" is cancer from long-term exposure to residual radiation. However, the radiation dose from such a bomb is likely to be relatively small. As an example, a bomb with a radioactive cobalt-60 rod used for food irradiation would deliver an average dose of a few tenths of a rem (see Units of Radiation) for people within a half-mile radius. The average person receives 0.3-0.4 rem per year from natural radioactive sources, and 5 rem is both OSHA's and the NRC's annual dose limit for nuclear and radiation workers. At such low doses it is impractical, if not impossible, to calculate long-term cancer risks, and both the Health Physics Society and International Council on Radiation Protection recommend against quantitative estimation of health risks below an individual annual dose of 5 rem, or a lifetime dose of 10 rem, above that of background radiation. These groups cite evidence that cancer risks from radiation exposure do not follow the linear, no threshold hypothesis used by the U.S. EPA. Instead, there appears to be a threshold (in excess of 10 rem delivered at high dose rates) above which the risk of cancer develops. In addition, biological mechanisms, including cellular repair of radiation injury, which are not considered by the linear, no-threshold model, decrease the chance of cancers and genetic effects.

[Note: The EPA, Federation of American Scientists, and others support the linear, no threshold model of radiation exposure. This view presents a worst-case perspective in which any exposure at all to radiation can cause cumulative biological damage, with less damage occurring at lower doses and more damage at higher doses along a linear progression. These projections lead to speculation that a RDD using cobalt-60, exploded at the southern tip of Manhattan under the right weather conditions, would render all of Manhattan uninhabitable until razed and rebuilt at a cost of 2 trillion dollars. Naturally, the media has picked this scenario to promote, adding to potential for panic and disruption.]

From a statistical perspective, for radiation, tumor induction is the most important long-term sequelae for a dose of less than 100 rem. These statistics, however, are extrapolations from known data on exposures greater than 100 rem, and, as stated above, such extrapolations are questionable. There is, however, reliable data showing that exposure to 10 rem causes a 0.8% increase in the lifetime risk of death from cancer. Thus, out of 5000 people with such an exposure, 40 may develop a fatal cancer.

Other known potential sequelae of radiation exposure, including cataract formation, decreased fertility and fetal teratogenesis, are unlikely to occur following the explosion of a RDD.

Decontamination

The most common contaminants will emit primarily alpha and gamma radiation, with minimal beta exposure. Gamma-radiation emitters may cause whole-body irradiation. Beta emitters when left on the skin can produce serious burns and scarring. Alpha radiation does not penetrate the epithelium. It is impossible for a patient to be so contaminated that he is a radiation hazard to health care providers; so medical or surgical treatment should not be delayed because of possible contamination. Most of the time, the simple removal of outer clothing and shoes will reduce contamination by 90%. External contamination of the skin and hair is from particulate matter that can be washed off. If practical, the clothing and effluent from washing should be sequestered and disposed of properly.

Internal contamination can occur when unprotected individuals inhale, ingest, or are wounded by radioactive material. The management of internal contamination more appropriately falls under the heading of 'Treatment.'

Signs and Symptoms

Radiation causes biological damage by direct and indirect means. When radiation interacts with atoms, energy is deposited, resulting in ionization (electron excitation). Such ionization can damage critical molecules or structures in a cell directly by hitting a particularly sensitive atom or molecule in the cell. The damage from this is irreparable and the cell either dies or malfunctions. Indirect cell damage occurs when the radiation interacts with water molecules in the body, resulting in unstable, toxic hyperoxide molecules, which can damage sensitive molecules and afflict subcellular structures.

The signs and symptoms of acute and chronic radiation poisoning are well described. Acute poisoning occurs following a nuclear blast and will not be seen with a RDD. The data on chronic radiation syndrome (CRS) is based upon victims who were exposed to radiation for at least 3 years and who had received at least 100 rem or more to the marrow. At the anticipated doses of a RDD, CRS is unlikely. For more information on acute poisoning and CRS, see the "Nuclear Blast Fact Sheet."

Response to a Dirty Bomb

With the threat of exposure to loose, airborne radioactive material, people are advised to move away from the immediate vicinity of the blast as soon as possible. Local TV and radio stations would begin broadcasts with instructions from emergency officials. Emergency management officials are responsible for providing immediate medical care to the injured, evacuating people to a safe zone, decontaminating people and equipment, and assessing the level of exposure. They will also determine the area to be cordoned off by police.

Treatment

Inhaled particles less than 5 microns in size will end up in the alveolar area, while the mucociliary apparatus will clear larger particles. Soluble particles are then directly absorbed into the blood stream or moved into the lymphatic system. Insoluble particles, until cleared, will continue to irradiate surrounding tissues. In the alveoli, the localized inflammatory response can produce fibrosis and scarring.

Absorption of ingested radioactive material depends on the solubility and chemical makeup of the contaminant. For example, cesium is rapidly absorbed; cobalt, radium, and strontium are not. The target organ for ingested radionuclides that pass unchanged in the feces is the lower GI tract. Gastric lavage and emetics can help empty the stomach promptly, while purgatives, laxatives, and enemas can reduce radioactive materials in the colon. Ion exchange resins limit gastrointestinal uptake of ingested or inhaled radionuclides. Prussian blue (Ferric ferrocyanide, an investigational new drug from Oak Ridge Affiliated Universities, Oak Ridge, TN) and alginates have been used in humans to accelerate fecal excretion of cesium-137.

The skin is impermeable to most radionuclides, but wounds and burns allow particulate contamination to bypass the epithelium. Also, fluid in the wound may hide weak beta and alpha emissions from detectors. Because of this, all contaminated wounds must be meticulously cleaned and debrided.

Once absorbed, a radionuclide crosses capillary membranes through passive and active diffusion and is distributed throughout the body. Organ metabolism, the ease of chemical transport, and the affinity of the radionuclide for chemicals within the organ determine the rate of distribution, with the liver, kidney, adipose tissue, and bone having greater capacities for binding radionuclides because of their high protein and lipid makeup.

Heavy metal poisoning is also a potential threat depending upon the isotope used. Chelation agents should be administered as needed. Calcium edetate (EDTA) is used primarily to treat lead poisoning but must be used with extreme caution in patients with preexisting renal disease. Diethylenetriaminepentaacetic acid (DTPA, an investigational drug) is more effective in removing many of the heavy-metal, multivalent radionuclides. Dimercaprol forms stable chelates with mercury, lead, arsenic, gold, bismuth, chromium, and nickel and may be considered for the treatment of internal contamination with radioisotopes of these elements. Another consideration is penicillamine, which chelates copper, iron, mercury, lead, gold, and possibly other heavy metals.

Specific Treatments:

- Americium-241: DTPA or EDTA chelation in the first 24 to 48 hours following pulmonary exposure is effective.
- Cesium-137: Prussian blue and ion exchange resins are useful. If early after ingestion, use lavage and purgatives.
- Cobalt-60: Gastric lavage and purgatives are advised for ingestions. Severe cases can be treated by chelation with penicillamine.
- Phosphorus-32: Treatment includes lavage, aluminum hydroxide, and oral phosphates.
- Radium-226: After ingestion, immediately lavage with 10% magnesium sulfate followed by saline and magnesium purgatives. Ammonium chloride may increase fecal elimination.
- Strontium-90: Immediately after ingestion, oral administration of aluminum phosphate can decrease absorption by as much as 85%. Administration of stable strontium can competitively inhibit the metabolism and increase the excretion of strontium-90. Large doses of calcium and acidification of the urine with ammonium chloride will also increase excretion.

Additional information and references available at http.www.bioterrorism.slu.edu

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Units of Radiation

Although the rad is still used widely as a unit of radiation, the current trend is toward use of the international unit called a gray (Gy), which may be used to describe all types of radiation. In man, higher energy radiation has greater effects as it is absorbed in tissue. A quality factor (QF) is used to adjust the difference. The dose in rads times the QF yields the rem (roentgen equivalent, man). The international unit for this radiation equivalency is the sievert (Sv) and is appropriately utilized when estimating long-term risks of radiation injury. Since the QF for x-ray or gamma radiation is 1, for pure gamma radiation: 100 rad = 100 cGy = 1000 mGy =1 Gy =1 Sv =100 rem.

Disclaimer

Information contained in this fact sheet was current as of September 2002, and was designed for educational purposes only. Medication information should always be researched and verified before initiation of patient treatment.

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