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Selected Topics: Disaster Medicine

NUCLEAR/RADIOLOGICAL TERRORISM: EMERGENCY DEPARTMENT MANAGEMENT OF RADIATION CASUALTIES

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□ **Abstract—Recent world events have increased concern that hospitals must be prepared for radiological emergencies. Emergency departments (EDs) must be ready to treat patients suffering from injuries in combination with radiation exposure or contamination with radioactive material. Every hospital should have a Radiological Emergency Medical Response Plan, tested through periodic drills, which will allow effective handling of contaminated and injured patients. Treatment of life-threatening or severe traumatic injuries must take priority over radiation-related issues. The risk to ED staff from radioactive contamination is minimal if universal precautions are used. The likelihood of significant radiation exposure to staff under most circumstances is small. Educating medical staff on the magnitude of the radiological hazards allows them to promptly and confidently provide the necessary patient care. Measures must be taken to prevent the "worried well" and uninjured people with radioactive contamination from overwhelming the ED. © 2007 Elsevier Inc.**

□ **Keywords—radiological emergency; radiological casualties; terrorism; dirty bombs; emergency planning**

INTRODUCTION

The concern that emergency department (ED) personnel will have to care for patients injured or contaminated by a terrorist act involving radioactive material has increased dramatically since the end of the cold war in the early 1990s. Sealed sources containing large amounts of radioactive material suitable for use by a terrorist are widely used in medicine and industry, and many large sealed sources have been lost from governmental oversight, particularly in developing countries and states that were part of the former Soviet Union (1). This article is intended to assist hospitals and emergency departments in preparing for nuclear/radiological terrorism and for accidents involving radiation injuries or radioactive contamination.

There are many possible terrorist radiation injury scenarios, including: 1) covert placement of a sealed radioactive source in a public location, 2) the use of a radiological dispersal device (RDD), 3) an attack on or sabotage of a nuclear facility, and 4) detonation of a nuclear weapon (atomic bomb), which is a remote but possible threat (1,2). A sealed source may be covertly placed in a location that would expose many people until the presence of the source is discovered. Although many people could be exposed, it is unlikely that any would be contaminated. An RDD is not a nuclear weapon; instead, it is a device designed to spread radioactive material for the purpose of terrorism. An RDD that uses a conven-

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tional explosive (e.g., dynamite or a plastic explosive) to spread the radioactive material is called a “dirty bomb.” Although the initial explosion may kill or injure those closest to the bomb, the radioactive material that is dispersed will likely expose and contaminate survivors and emergency responders. Due to the limited dispersion by such an explosion, it is unlikely that the exposure or contamination of people outside the immediate blast area will have any clinical effect beyond the psychological impact from the fear of radiation and perhaps a slightly increased risk of cancer. To date, there has been no use of an RDD; however, the materials to produce an RDD have been intercepted by law enforcement (3).

An attack on or sabotage of a nuclear facility, such as a commercial irradiation facility or a nuclear power plant, could release large amounts of radioactive material. Detonation of a nuclear weapon (even one with a relatively low energy yield) in a populated area would result in extensive loss of life and widespread contamination. The use of a stolen or improvised nuclear device is the least likely scenario, due to the strict security controls over nuclear weapons and weapons-grade plutonium and uranium and the technical difficulty of constructing such a weapon, but the potential number of injured people is many times greater than from the other scenarios. In the case of a nuclear weapon detonation or an event resulting in the dispersion of used nuclear reactor fuel, the radioactive contamination will consist of many radionuclides, including radioactive isotopes of iodine.

In all scenarios involving the release of radioactive material, radioactive contamination would be present at the site of the event. There may also be deposition of radioactive material by a downwind plume. The amount of contamination deposited by the plume would depend upon the nature of the event, the amount of radioactive material released, and atmospheric conditions such as wind speed.

There are several scenarios, other than those caused by terrorism, in which radiation emergencies may occur. Some examples include medical radiation therapy accidents; accidental overexposures from industrial irradiators; lost, stolen, or misused medical or industrial radioactive sources; accidents during the transportation of radioactive material; and nuclear reactor accidents. The Radiation Emergency Assistance Center Training Site (REAC/TS) recorded 428 major radiation accidents worldwide between 1944 and 2005, resulting in 126 radiation-related deaths (4). Although these accidents were infrequent, heightened awareness of the potential impact from terrorist activity has prompted many hospitals to reassess their preparedness for radiological emergencies.

IONIZING RADIATION AND RADIOACTIVE MATERIAL DEFINITIONS

Ionizing Radiation

Ionizing radiation, such as X- and gamma rays as well as alpha and beta particles, has the ability to ionize matter, causing chemical changes that can modify DNA and kill cells. Throughout this article, the term *radiation* will refer only to ionizing radiation. Radiation is a natural part of the environment. People are constantly exposed to radiation from their surroundings, (e.g., the earth itself, building materials, air, and water) as well as from cosmic rays. On average, persons in the United States receive about 300 millirem (mrem) of radiation per year from natural sources (5). People are also exposed to manmade radiation from medical imaging (e.g., radiology and nuclear medicine studies), medical therapy (e.g., cancer treatment), industry (e.g., soil moisture density gauges and nuclear power plants), and research.

Radioactive Material

Radioactive material consists of atoms with unstable nuclei. The traditional unit of activity is the curie, defined in Table 1. Contamination of people usually involves microcurie (μCi; one millionth of a curie) to millicurie (mCi; one thousandth of a curie) quantities. Nuclear Medicine patients are injected with μCi to mCi quantities of short-lived radioactive material for routine diagnostic examinations. The amount of radioactivity continuously decreases with time, a phenomenon referred to as radioactive decay. The physical half-life is the time required for radioactive material to be reduced to half the initial amount by radioactive decay. The effective half-life combines the physical half-life with biological elimination (e.g., urination, defecation, exhalation, and sweating). Most of the radionuclides that are considered likely to be used in an RDD (see below) have physical half-lives of 5 years or more.

Two common types of radioactive decay are alpha particle emission and beta particle emission. Alpha particles travel very short distances (< 0.1 mm) and therefore, are only harmful when alpha-emitting radionuclides are inhaled, swallowed, or present in a wound. Some beta particles can travel up to 10 meters or more in air and a centimeter or more in soft tissue. Thus, most beta-emitting radioactive materials, if allowed to remain on the skin for a prolonged period of time, can cause skin injury. Beta-emitting contaminants may also be harmful if deposited internally. Gamma radiation and X-rays are also emitted by many radioactive materials and travel many meters in air and many centimeters in living tissue.