Ionizing Radiation Injuries and Illnesses

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KEYWORDS

• Acute radiation syndrome • Hematopoietic syndrome • Cutaneous syndrome
• Cutaneous radiation syndrome • Acute local radiation injury • Radiological • Nuclear

KEY POINTS

- Ionizing radiation injuries and illnesses are usually delayed, with the exception of extremely high or fatal doses.
- Stabilize medical and surgical conditions before dealing with radiological issues.
- Remove victim from contaminated area and remove potentially contaminated clothing using radiation protection principles.
- Obtain medical history and physical examination to include pertinent negatives.
- Obtain incident history and summon physics expertise to assist with radiation dose estimations.

INTRODUCTION

The spectrum of information related to diagnosis and management of radiation injuries and illnesses is vast. It is assumed that most physicians in practice have little or no remembrance of materials taught in secondary school or college about physics and

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units of measurement. A very brief overview will be provided. Ionizing radiation injuries and illnesses are very rare, as are contamination incidents involving radioactive materials (REAC/TS Radiation Accident Registry). Most health care providers have had little to no experience with such cases, with perhaps the exception of those working in radiation oncology or nuclear medicine, where diagnostic and therapeutic application normally occur.[1] Furthermore, many medical school curricula do not include information about Disaster Medicine including radiological and nuclear hazards[2]; this is despite the fact that radiation sources (radioisotopes) enjoy widespread use in industry (eg, oil, gas, electrical power, and engineering); food, blood, and medical supply treatment; the military; research, and medicine. The US Nuclear Regulatory Commission and the States maintain approximately 22,000 radioactive materials licenses.[3] Exposures to ionizing radiation and internal contamination with radioactive materials can cause significant tissue damage and conditions. Emergency practitioners unaware of ionizing radiation as the cause of a condition, may miss the diagnosis of radiation-induced injury or illness. A review of the pathophysiology and medical management of radiation injuries and illnesses is thus important to fill this gap.

APPLICABLE PHYSICS

Radiation is generally defined as energy that is propagated through space.[4] A basic understanding of physics is necessary to fully apprehend the injuries that may result from radiological incidents. Radioactive materials are substances that emit ionizing radiation in an effort to reach nuclear stability. Ionizing radiations have sufficient energy to create charged particles, that is, ions, by the removal of a negatively charged electron from an atom. Electrons circle in orbits around central atomic nuclei made up of positively charged protons and electrically neutral neutrons.[5–9] Removal of an electron from such an atom would create 2 ions: the negatively charged electron and the positively charged atomic remnant. If ionization occurs in a biologically important molecule like a strand of DNA, the genome may not be able to function properly.[10]

Types of Ionizing Radiation

There are only a few ionizing radiations of concern for practical medical purposes: alpha particles, beta particles, positrons, and neutrons, plus the pure electromagnetic energy radiations gamma rays and X rays. All of these radiations, with the exception of X rays, are emitted from the nuclei of unstable radioactive atoms. X rays can be machine produced or can occur when electrons drop to lower energy orbital shells due to "self-ionization" of radioactive atoms.[5–9]

Alpha (α)

An alpha particle consists of 2 protons and 2 neutrons and has a +2 charge associated with it. It is very effective at ionizing other atoms and deposits its energy rapidly across its linear path. For medical purposes, this is important because an alpha particle can travel no more than a few centimeters in air and, as a general rule, cannot penetrate the outer layer of dead human skin. Alpha particles are therefore an internal hazard only. Materials that emit alpha particles pose a radiological hazard only if taken into the body via inhalation, ingestion, or if they enter the body via a contaminated wound. A sheet of paper is an effective shield for alpha particles (**Fig. 1**).[5]

Beta (β)

A beta particle is identical to an electron; however, because of some nuclear transformations it is emitted from the nuclei of some radioactive materials. Negatively charged beta particles, typically thought of as negatively charged, can penetrate further than