

Radiological Incidents and the Florida Physician

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Introduction

The concept of nuclear energy and radiation evokes visions of mushroom clouds, melting flesh, and cancer in the minds of many people. I can remember many years ago as a nuclear engineering sciences student at the University of Florida staffing a booth for the student chapter of the American Nuclear Society. A young woman walked up to me and before I could say a word said, "I don't know anything about nuclear energy, I just know I don't like it", and then walked away. Thirty years later, I still vividly remember this incident.

And so it goes with our nuclear power industry that a sizeable number of our population, influenced by the inventiveness of our entertainment industry, the memory of Chernobyl, and the horrors of Hiroshima, feel that anything nuclear is bad and dangerous to our safety and health. The truth is that there are risks in everything we do. The risk of using nuclear energy for power generation or x-rays to improve oral health is very well known and has been studied for well over 100 years since before Madame Curie's discovery of radium. The risk to our nations' economic viability is real when one considers that we transfer about \$660 million PER DAY to foreign countries and intermediaries for oil imports into the United States while we continue to refuse to conserve this dwindling resource¹.

Radiological Health 101

Ionizing radiation is released when an unstable atom seeks to become stable and emits energy, thereby, making it radioactive. This energy can be particulate and/or electromagnetic. Ionizing radiation can have adverse biologic effects including the production of free



radicals, disruption of chemical bonds, and potentially irreversible damage to DNA.

Sources of radiation are either naturally-occurring or man-made. Examples of naturally-occurring sources of radiation include: cosmic rays that are constantly streaming onto our planet from space; primordial radiation that is emitted from material in the earth's crust such as radon; and cosmogenic radionuclides that are produced when cosmic rays interact with atoms in our atmosphere producing substances such as carbon-14. Man-made sources of radiation consist of: radiology devices and radiopharmaceuticals used in diagnostics and therapeutics; the nuclear power industry; various consumer products such as smoke detectors containing americium-241; certain industrial products such polonium-210 containing static

eliminators; and, the fallout from the Cold War atmospheric detonation of nuclear weapons.

There are five types of ionizing radiation about which a physician should be knowledgeable. Particulate radiation consists of alpha particles (an ionized helium nucleus), beta particles (an electron from around the atom's nucleus), and neutrons (removed from the nucleus of the atom). Electromagnetic radiation includes gamma and x-rays. Alpha radiation is primarily an internal hazard if ingested, inhaled or absorbed from a wound. Externally, it has little >>>

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penetrating ability. Beta radiation is hazardous externally and internally but to differing degrees. Neutrons mainly pose a human health concern when associated with a nuclear weapon detonation and are capable of making objects and people actually radioactive.

Since it is highly penetrating, electromagnetic radiation is the most potentially damaging from external exposures, especially gamma rays. In addition, gamma ray emission is usually associated with release of a beta or alpha particle from the unstable atom which adds to the potential for biologic effects.

Radiation exposure can be characterized as external, internal, partial body or whole body. Some radioactive materials when internally absorbed are specific for one organ system such as radioactive iodine and the thyroid gland. The biologic effects of radiation depend on the cells exposed with the severity of tissue damage from most to least radiosensitive being: lymphoid > gastrointestinal > reproductive > skin > muscle > nervous system. The embryo/fetus is much more radiosensitive than the child or adult.

The amount of energy absorbed by tissue quantifies its radiation dose. In general, the higher the dose absorbed by the individual, the greater the potential for acute (deterministic) effects. Lower doses lead to increased risk for long-term (stochastic) effects such as cancer.

Historically, the basic unit of quantification of dose was the “radiation absorbed dose” (rad), but this term has been replaced by the Système Internationale (SI) unit, Gray (Gy). For human radiation dose effects, the “röntgen equivalent man” (rem) is still used, and its SI unit is the Sievert (Sv). One Sievert (1 Sv) is equivalent to 100 rem, or more conveniently, one millisievert (1 mSv) is equal to 100 millirem (100 mrem).

Every day, each of us is exposed to radiation from natural and manmade sources. On average in the United

States, the annual background whole body radiation dose is 360 mrem (3.6 mSv) from all causes. Acute high-level doses of radiation in excess of 70 rem (0.70 Sv) can produce symptoms including nausea and vomiting, and with higher doses, can lead to acute radiation syndrome (ARS). The dose at which one half of all individuals will die in 60 days without medical care is about 350 rem (3.5 Sv) (the so-called Lethal Dose₅₀ or LD₅₀). At these doses, the hematopoietic system is affected producing pancytopenia. Post-irradiation lymphocyte counts correlate inversely with absorbed radiation dose such that decreases in absolute counts of 50 percent within one or two days of an exposure indicate that a dose of 300 to 600 rem (3 to 6 Sv) has been received. With doses over 800 rem (8 Sv), the gastrointestinal syndrome is seen secondary to damage to the GI mucosa, and is featured by vomiting within minutes of exposure, massive diarrhea, and subsequent sepsis. Death usually occurs within days without life-saving interventions. At doses over 2000 rem (20 Sv), the neurovascu-

lar syndrome is evident including rapid onset of nausea, vomiting, hypertension, decreased sensorium, convulsions and death, irregardless of attempts at treatment.

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Minimizing an individual’s exposure to radiation to “as low as reasonably achievable” (ALARA) is important in reducing possible biologic effects. Some potential radiological incidents involve the spreading of radioactive material over a wide area (several hundreds of meters to kilometers in radius or downwind). This radioactive material on the ground, in the air, or adherent to structures is termed contamination. Preventing people from becoming contaminated or from receiving a radiation exposure is premised on three basic principles of radiation protection: time,

distance, and shielding. In essence, the shorter the amount of exposure time, the further an individual is away from, and the greater the amount of any material between the individual and a source of radiation or contamination, the less the dose they will receive, thus, minimizing the potential biologic effects.

What is the Nuclear/Radiological threat?

There are two basic etiologies of nuclear/radiological threats – accidental and man-made (terrorism). Ever since radioactivity was discovered at the end of the 19th century, we have known that accidentally or intentionally, it could harm humans and their property.

There have already been numerous accidents involving radioactive materials. Transportation incidents do occur on our nation’s highways. Individual radiation emitting sources used in medical and industrial applications are lost, stolen or misplaced with some regularity. In addition, releases of radioactive materials from nuclear reactors, especially the Chernobyl incident, have made

world-wide headlines and do need to be closely monitored and regulated for health as well as possible proliferation reasons.

Radiological terrorism involves the use of radioactive materials to irradiate or contaminate a non-military area or population. Because of current intelligence information and from recent history of actual terrorist activities, there is strong opinion from experts, that it is not a question of if, but when, a significant radiological terrorist event will occur.

There are four basic scenarios that can lead to the release of radioactive material with terrorism intent. One scenario involves the detonation of a nuclear device, either improvised or a stolen military nuclear weapon. >>>

The second scenario deals with the dispersal of radioactive material in an area especially if associated with an explosive device. The third scenario involves the placement of a radiation-emitting source in an inappropriate location. Lastly, an attack on a nuclear power reactor could cause radioactive material to escape from the plant site.

An *Improvised Nuclear Device (IND)* is a conceivable weapon of the terrorist although adequate amounts of weapons grade uranium or plutonium are difficult to obtain and the technology to engineer the weapon is complex. A more likely occurrence would be a well-financed terrorist group acquiring a missing tactical military nuclear weapon on the Black Market. The result of even a “small” nuclear detonation would be the death and injury of tens of thousands of people and significant politico-economic effects for years to come.

A *Radiological Dispersal Device (RDD)* could simply scatter radioactive material over an area or be attached to explosives creating the so-called “dirty bomb.” The radioactive material involved could come from a variety of sources including spent nuclear generating fuel, nuclear medicine radiopharmaceuticals, radiation teletherapy or brachytherapy sources, or various industrial devices. It must be emphasized that the use of a “dirty bomb” is not a nuclear explosion. It is unlikely that the RDD would use nuclear materials (fissionable) since they are difficult to obtain and dangerous to handle. The resultant contamination from an explosive RDD, once discovered, would surely disrupt the local, state, and perhaps even national economy, depending on where it is set off, and, possibly irregardless of the amount of radioactive materials released. The main human hazard from an explosive RDD is the initial blast, with the ensuing contamination problematic, but controllable. A non-explosive variant of the RDD was the recent use of polonium-210 as a weapon of assassination in London.

Radiological Exposure Devices (RED) are radioactive sources that are usually

found in commercial/industrial activities such as non-destructive weld testing, soil moisture probes, and other applications. A plausible terrorist scenario would be to place these very small but highly active sources in taxis, buses, or trains that would provide high radiation doses to many individuals over a short period of time. This terrorist act would perhaps only be discovered epidemiologically by linking several cases of acute radiation symptomatology by person, place, and time.

A *terrorist attack* on a nuclear reactor is conceivable but would be difficult to carry out. Even before 9/11, U.S. nuclear reactor sites have had maximum security and access would be very difficult for unauthorized individuals. Flying an aircraft into the reactor core building would surely disrupt operations, but, according to most experts, would probably not result in a significant breach of the nuclear materials containment facility.

Disaster Medical Management

Any significant radiological disaster would be followed by a coordinated local, regional, state, federal, and possible international response. The National Incident Management System² (NIMS) mandates the use of the well-tested principles of the Incident Command System (ICS) to manage an all-hazards disaster caused by natural or manmade means. ICS has been used in Florida to manage the hurricane-related disaster response over the past few years. The Incident Command System provides a universal operational structure and is employed by all disaster response disciplines including law enforcement, fire/rescue/HAZMAT, emergency management, emergency medical services (EMS), public health, and hospitals (as the Hospital Emergency Incident Command System (HEICS))³.

The format of this article does not permit a detailed description of the specific medical response after a radiological disaster. The Armed Forces Radiobiology Research Institute (AFRRI) has a handbook available on-line entitled, “Medical Management of Radiologi-

cal Casualties,⁴” that is a primer for physicians on patient management. In addition, the federal Department of Health and Human Services recently introduced a new website, “Radiation Event Medical Management⁵ (REMM),” which is designed to provide guidance to health care professionals, primarily physicians, about clinical diagnosis and treatment during mass casualty radiological/nuclear incidents.

There are a number of myths relating to the care of injured and contaminated individuals secondary to a radiological incident. We will debunk these myths and then briefly look at hospital response efforts.

Myth #1 – *Radioactive contamination is highly dangerous and requires extraordinary protective measures.*

Fact #1 - *Emergency departments and other treatment locations may become contaminated after handling patients from an RDD or similar incident.*

- All acute care hospitals need to have a plan for handling radioactively contaminated patients. See the national Health Physics Society Web site for a PowerPoint presentation on “Hospital Response Following a Terrorist Event Involving Radioactive Material.”⁶

- In general, radioactive contamination is not immediately dangerous to life and health and is easily managed using basic protective practices including personal protective equipment (PPE) and good hygiene (Universal precautions).

- The fact is that radioactive contamination (unlike chemical or biological agents) presents little hazard to the treating medical staff.

Myth #2 – *Decontamination of the patient is the highest medical concern.*

Fact #2 - *There are few, if any, medically or scientifically valid reasons for withholding medical treatment for radioactively contaminated patients. See the national Health Physics Society Web site for a PowerPoint™ presentation entitled, “Emergency Management of Radiation Casualties.”*

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- The consensus of opinion is that although radioactive contamination may present as a health issue over the long term (years), it is not an immediate threat to the life and health of the patient and staff.

- The bottom line is that if the patient requires immediate medical intervention, treat the patient, and then decontaminate.

Myth #3 – *You need special training to handle radioactive patients.*

Fact #3 - *A modification of OSHA-mandated bloodborne pathogen training is primarily what is required to handle contaminated patients.*

- Since radioactivity cannot be sensed, radiation meters (such as Geiger counters) found in (prepared) hospitals are needed and staff should be trained in their use.

- 80 percent of contamination can be eliminated by removing the patient's outer clothing and much of the rest by washing with soap and water the patient's exposed areas including the face, hair, and hands. All contaminated clothing should be bagged and labeled for later appropriate handling.

- Most hospitals with nuclear medicine or radiation therapy capability will have health physicists and their equipment available to assist in patient monitoring.

Myth #4 – *Potassium iodide (KI) will protect you from radiation exposures.*

Fact #4 - *Potassium iodide given before or shortly after an ingestion of radioactive iodine (such as iodine-131) will block the uptake of the radioactive iodine into the thyroid gland. The most likely incident causing the release of radioactive iodine would be from a nuclear reactor accident or terrorist attack resulting in a breach of the reactor core containment.*

- Potassium iodide will not protect you from external exposure to radioactive iodine or the internal ingestion of or external exposure to ANY other radioactive material.

- There are other substances that will aid in the elimination of internal deposition of radioactive materials. For example, Prussian blue is used to remove cesium-137 and calcium and zinc DTPA are effective in chelating plutonium.

- Although research is continuing, there are NO substances that effectively, and with minimal side effects, protect humans from external radiation exposures.

Triage and initial care for victims of a radiation incident is begun by EMS until they arrive at a hospital. Definitive care begins in the (prepared) ED by further assessment and treatment of life-threatening injuries. All the resources of the hospital would be needed to care for radiation victims. This would be overwhelming in the case of a nuclear weapon detonation, but more manageable after an RDD or smaller incidents. In addition to emergency department staff and radiation safety and other personnel from radiology and nuclear medicine, the hospital response would include intensive care specialists, burn specialists, hematologists, radiation oncologists, pathologists and more. In a moderate to large event, patients would need to be transferred out of the region to specialty care facilities. The Radiation Emergency Assistance Center/Training Site⁸ (REAC/TS) located in Oak Ridge, TN is an international leader in emergency medical response to radiation incidents and should always be consulted (865.376.1605) for advice on handling externally exposed or internally contaminated individuals.

Of immediate concern to hospitals and public health would be the number of "worried well" or those that are or think they are contaminated, self-referring to hospitals or other locations. With appropriate preparation, Alternative Medical Treatment Sites (AMTS) could be set up to provide radiation screenings, decontamination, and dissemination of medical information. Behavioral health counseling should also be available. The AMTS's would be open from a few hours to several days to handle the influx of these types of individuals.

Physicians may be consulted by emergency managers to assist in decision-making regarding evacuation and sheltering of the public both in the early and long-term phases of a significant radiological incident. If sufficient knowledge is available beforehand of a radioactive release, i.e., from a nuclear power plant, then evacuation may be appropriate. With a nuclear weapon detonation or an explosive RDD, the plume of radioactive materials lasting from minutes to hours could make initial evacuation hazardous so the recommendation may be to shelter-in-place. Simply stated, sheltering-in-place means staying wherever you are - at work, in school, or at home, closing windows and doors and turning off all ventilation systems, until directed to leave. This would have to be time-limited sheltering (multiple hours) due to personal/individual concerns and needs for food, water, medications, climate control, etc. Long-term sheltering and evacuation will require significant resources and those decisions are made by emergency management as the situation dictates.

Physician and Community Preparedness

The AMA report, "Medical Preparedness for Terrorism and other Disasters,"⁹ is an excellent resource for physicians on all-hazards disaster preparedness and response. In addition, in Florida, the AMA has offered Basic Disaster Life Support¹⁰ training (BDLS) presented by the Florida State University College of Medicine at the FMA Annual Meeting and other venues around the state. This is a valuable course that every physician should take in preparation for all-hazards disasters.

Most physician preparedness and response issues are common to any type of disaster. Because all disasters are local, the national mission areas of prevent, protect, respond, and recover in any disaster are also critical to local preparations. The following points should be considered by every physician in preparing themselves and their community for a disaster.

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1. Obtain training/education in all-hazards disaster preparedness and response by attending lectures, reviewing journal articles or CD-ROM's, and by accessing disaster-related Web sites^{11, 12}.

2. For most radiological incident situations, the physician will be most useful by continuing to perform their daily work schedule, as feasible.

3. If the medical infrastructure is so significantly disrupted by an incident, a redirection of the physician's practice may be necessary until normality returns. After a disaster, contact your local county health department regarding the operational status of your practice.

4. Physicians can volunteer now for disaster medical staffing groups such as the Medical Reserve Corps that are affiliated with many county health departments. The request to provide medical assistance for disasters outside of the physician's area would usually be made through the Florida Department of Health and would be coordinated by your local health department.

5. All physicians should know how they fit into their hospital(s) or other health care facility(ies) disaster plans before a disaster occurs. You may be asked to augment your hospital's medical surge capacity in a disaster situation.

6. Physicians should know their role in their community's disaster plan since they are a vital component of the health and medical infrastructure.

7. Physicians should understand how they may need to interact with their local county health department after a disaster due to the need for continued disease reporting and long-term follow-up of affected individuals.

8. Become a member of your county medical society. In most communities, the health department and the medical society work together before a disaster by providing education and training, and following a disaster, by assisting in coordinating health care resources.

9. Become a member of the Florida Medical Association. Because Florida has been the victim of numerous disasters, the FMA maintains a Committee on Disaster Preparedness¹³ which makes recommendations to physicians on disaster preparedness and response issues.

10. Physicians are one of Florida's most vital resources during disasters. Don't allow yourself to become a victim of a disaster. Consult your county's emergency management Web site for information on local disaster planning for you, your staff, and your family. ●

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