Very brief radiation exposure primer and terminology review

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In dealing with exposure hazards to responders, there are many issues to consider and it may be beneficial to quickly review concepts even if only superficially. While the responder community has had training in this arena, assessing risk from exposure to victims and responders is a very complex and challenging issue. It is of prime importance to note that any dose of radiation can be hazardous (large dose or small). We know that a true nuclear detonation (bomb blast) poses immediate risks from explosive force-both blunt and penetrating trauma. However, the additional risk from radiation injury -immediate and delayed- must also be assessed during the entire course of the event.

The effect of less lethal amounts of radiation is also a very complex issue. The guiding principal is the Acronym ALARA for "As Low As Reasonably Achievable." --- making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical. Also, an excellent risk assessment discussion can be found on the Health Physics Society website-a great resource for information.

Radiation exposure poses many challenges. First and foremost, radiation exposure is medically undetectable to the senses and can cause great fear in victims who are not aware of the extent of their exposure and consequent risk of injury. However, radiation is easily detectable at its source by survey meters. *Note that this does not qualify the extent of exposure to victims and responders over time.*

We are familiar with the so called Dirty bomb—also known as an RDD (Radiation Dispersion Device). The RDD is a very serious and potentially dangerous event, said to employ a convention explosion to spread radioactive material and offer hazards to victims, responders and the environment.

A nuclear detonation of a concealable device, often called a SND (Suitcase Nuclear Device) can cause lethal injury to multiple victims from both trauma and radiation. Trauma, secondary to explosive energy and burns, collapsing structures and flying debris, are immediate hazards overwhelming local responder resources. However, there is also a radioactive hazard from the detonation that can last for many days, even weeks. The danger to victims and responders from a radiation hazard is very complex. Obviously, this poses challenges to triage and medical stabilization at the scene as well as an indefinite timeframe post incident.

For these reasons, continued relevant information is of great importance to maintain currency. In the previous articles, we alluded to assistance from the academic community. In this case, the Health Physics community is robustly capable of offering assistance, teaching, research etc. One of their important contributions is offering very practical advice, suggestions and helpful websites. It is relatively easy to access these communities in addition to the DOE (www.energy.gove), ORISE (http://orise.orau.gov/) and in local groups such as the Health Physics Society http://www.hps.org/meetings/ . Both have strong membership and support from the first responder community. These groups of highly trained professionals also have fact sheets that can be of great assistance. One example is: http://hps.org/hpspublications/radiationfactsheets.html

In addition, a very helpful section on this website appears to be the radiation terminology (from a-z) and can be found at: http://hps.org/publicinformation/radterms/

We strongly urge involvement by first responders in such groups. There are many other groups offering assistance that we are not attempting to exclude but the two groups mentioned offer publications, meetings and courses that could possibly open many new vistas for learning and trust.

For the purpose of this article, we provide a very brief review of terminology of radiation exposure. Radiation exposure is very anxiety provoking due to the fact that injury can occur that is not initially detected by the senses. In general, for simplicity, let's just consider the four principle types of radiation that can cause injury and could be a threat to health in the event of a potential nuclear event scenario. Unfortunately, each type of radiation can be lethal in and of itself depending on dosage, proximity at the time of exposure, and other variables.

Alpha- a large particle often said to be stopped by intact skin or a uniform. This may sound innocuous but can be hazardous. This type of radiation can be shielded fairly easily but nonetheless poses direct hazard to responders and victims due to the issue that inhaled or ingested, alpha radioactive particles can pose a very important threat and must have special consideration. The hazard of alpha radiation is due impart by route of exposure, such as inhalation and ingestion and also from exposure through an open radioactively contaminated wound. Special attention is necessary for such wounds and for the prevention of exposure from other routes that require careful decontamination protocols.

Hands-on training is available to first responders but these issues very obviously pose challenges to triage and medical stabilization at the scene.

Beta contamination- a small fast moving particle that may penetrate shielding, has very high energy and can also result in thermal like burns to the skin of victims exposed to the initial flash of a nuclear detonation.

Gamma- the ray or wave energy form that travels long distances and requires very thick lead shielding to be attenuated. Again, the amount of shielding is a complex issue and depends on dose or amount of exposure. This ray causes direct, lethal biologic damage. Often employed in cancer treatment, this ray can alter biologically active molecules and can be directly lethal to cells or cause damage that is overwhelming to biologic repair mechanisms.

Radiation – A Very Brief Study:
It may be beneficial to review some standard radiation terminology however; this review is not meant in any way to be comprehensive. Periodic course work may be beneficial to review these issues.

The RAD (Radiation Absorbed Dose):
The RAD refers to the ionizing radiation dose (either from initial detonation or from fallout). Also the RAD is in use in many radiation survey meters (old terminology Geiger counter).

The REM (Roentgen Equivalent Man):
A unit in the traditional system of units that measures the effects of ionizing radiation on humans (see Health Physics website) and is a measure of biologic injury. For this discussion, it can be considered very close to the same value as the RAD. In addition to the dosage, one must be familiar with the different kinds of ionizing radiation.
Again, for the purpose of this discussion the term RAD can often be considered equivalent to the REM or biologic dose. For simplicity, we could consider that 100 RAD = 1 Gray. The assumptions may hold true since, as first responders, we often deal with larger doses of radiation and our focus is triage concepts and transport of patients in the first care scenario. Again, it is important to emphasize that any dose of radiation can be hazardous.

A nuclear detonation also emits x-rays and neutrons and can often be more biologically damaging than gamma rays. These two hazards are usually considered brief in duration and in the area of the blast. The nuclear blast itself causes conventional traumatic injury from the intense overpressure with flying and falling debris near the epi-center similar to a tornado or earthquake, as well as thermal burns (heat energy) and injury due to radiation exposure. There is also a significant, potentially lethal risk from radiation alone in the initial burst area.
These two threats can activate metallic substances/debris and make radioactive-emitting gamma rays after called “fallout”.

What is EMP?
Electromagnetic pulse (EMP) is not completely understood and very difficult to quantify. We know that there is an electronic pulse created by a nuclear chain reaction that can disrupt electronic circuits, transistors and other electronics such as computers. Unfortunately, this may include ignition systems in vehicles and may cause vehicles to stall and be unable to start. This phenomenon only occurs in the area nearby a nuclear chain reaction type explosion. It is difficult to say how far from the epicenter that it might extend. Resources may be needed from areas outside this zone and vehicles may block streets inside this zone. Travel in and out of the scene might be significantly impeded by the EMP or electromagnetic pulse that permanently disables unprotected electronic equipment and vehicles and could possibly create roadblocks of disabled vehicles for an estimated several miles radius from the epicenter of the blast. EMP would not affect equipment brought in from unaffected areas but unprotected electronic gear might be affected. Unshielded Radio repeaters might need to be replaced or substitution made depending upon the distance from the epicenter.
Reference: Health Physics Society website

What is fallout?
In addition to blast and thermal trauma after a nuclear detonation, the newly created radioactive material called “Fallout” is caused by debris sucked up into the fireball cloud and then falling back to earth with the potential for radiation injury. This fallout can cause very significant whole body radiation exposure and can possibly contain lethal levels of radiation without being immediately detectable to the senses. Another form of radiation can cause burns to the skin. Gamma radiation can be absorbed by the body initially, unnoticed by the senses. However, all types of radiation are very detectable with devices called survey meters (as long as calibrated, equipped with fresh batteries and user or operator friendly).

This radioactive fallout or residual radiation from by-products of nuclear fission usually falls to earth in a downwind conical shaped plume somewhat similar to chemical contamination scenarios. This contamination can occur over a period of several days in a downwind type distribution. After the material settles back to earth, this radioactive material may take days to weeks to decrease in intensity and approach the US Government regulatory radiation levels considered safe for human exposure. The radioactive fallout can be quite large (many square kilometers) and can eventually extend hundreds of miles with worrisome contamination.
Radiation can pose a threat to vulnerable populations who often suffer the grates potential injury for this type event.

In conclusion, these issues pose a very complex arena of threats to victims and responders. However, most types of radiation contamination are detectable with instrumentation by trained personnel. These hazards lend themselves to preparation—both in planning and equipment to assess risk to responders. Each responder should have detection equipment available to measure both real time exposure and accumulated dose so they may assess a potentially dangerous risk- both immediate and delayed.

Both new technology and new operation techniques should be considered in the effort to cope with this challenge. Much attention must be drawn to real time quantification and exposure. Perhaps a meter or instrument could be designed not only to qualify, but to keep count of exposure time and amount and provide an alarm function to warn of possible limit.

Real-time measurement and personal dose meters are needed that would calculate instantaneous but also accumulated dose with possible output connections to team leader/section chief incident command to assist in monitoring. This would enable us to know the total time responders can safely be in the hot zone to allow for seamless workforce rotation policy, if necessary.

This could be tied in with onsite assessment teams—who may be required to perform reconnaissance functions in vehicles, drone vehicles, or robotic equipment. Again, the most important factors are time of exposure, distance from source and shielding.

Secondly, devices such as drones could be of assistance in determining the amount of radiation and fly into the scene to offer video input to assist in obtaining routes onto the scene. The same technology already exists to monitor operations in military action. Third, the EMP damage assessment must be made accurately and without delay. There would be obvious failure of unprotected electrical equipment. Circuits might fail that result in a wide area affected far outside the scene. There would be damage to electrical devices and disabling of vehicles causing problems with medical response and medical evacuation. Fourth, the use of computer assisted plume measuring devices could greatly assist; this technology was developed for the WTC tragedy of 911. Fifth, gathering of all data on effects of low level radiation exposure that already exits in military and government data base analysis with an eye toward identifying groups of higher or lower vulnerability.

Finally, the ominous issue of combined injury from a combination of trauma and from radiation exposure must be used to create new triage categories that account for the increase in the triage category associated with radiation exposure.

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