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Title: EMERGENCY MEDICAL RESCUE IN A RADIATION ENVIRONMENT

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EMERGENCY MEDICAL RESCUE IN A RADIATION ENVIRONMENT

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SUMMARY
Previous experience with emergency medical rescues in the presence of radiation or contamination indicates that the training provided to emergency responders is not always appropriate. A new course developed at Los Alamos includes specific procedures for emergency response in a variety of radiological conditions.

I. INTRODUCTION
Consider a scenario. An explosion occurs in a room where radioactive materials are being processed. The sign at the entrance reads: Danger, High Radiation. In the room, a worker is lying unconscious, splattered with radioactive material, and with bright red blood spurting from a head wound.

In this situation, what would and what should be the response of a responder such as an emergency medicine technician (EMT)? In previous accidents involving radioactivity, the response has varied. As examples, we discuss three cases.

A. SL-1
In 1961, a criticality accident at the SL-1 test reactor[1] caused a high-pressure explosion from the reactor vessel, killing three technicians who were reassembling the control rods. A seven-man crew responded from the National Reactor Testing Station Fire Department in Idaho. In addition to their standard "turnout" (or bunker gear) and self contained breathing apparatus (SCBA) they had a radiation detector, film-badge dosimeters, and direct-reading pocket dosimeters. They proceeded cautiously through the empty rooms, and had reached the deserted control room, where the dose rate was 0.1 Gy/h (10 rad/h) when experienced health physics personnel arrived.

An hour and twenty minutes after the accident, two victims were found in the reactor room, where the dose rate was about 10 Gy/h (1000 rad/h). One, who showed signs of life, was extricated by a five-person team but was pronounced dead a few minutes later. The team of health physicists and supervisors each received a dose of about 0.25 Gy (25 rad). Although it took time to locate and rescue the live victim, it is generally considered that this rescue went about as well as could be expected.

B. Chernobyl
The 1986 accident at the Chernobyl reactor[2] provides a second example involving emergency response and rescue from a very high radiation field. Twenty-nine people died of acute radiation syndrome as a result of working for several hours where dose rates were about 10 Gy/h.

In contrast to the fire department at SL-1, the responders at Chernobyl wore clothing that was permeable to dust, water, and contamination. They had no respirators, no radiation detector, no dosimetry, and appear to have taken few if any measures to protect themselves from ionizing radiation or radioactive material. Of the 7-man fire-department crew who were first on the scene, 6 died of acute radiation syndrome. We question whether this emergency response went as well as it could have.

C. A Los Alamos Exercise
A third example that provides a lesson was a training exercise at Los Alamos. A simulated "victim" was stated to be contaminated with 100 dpm/100cm^2 of plutonium, though with no measurable external radiation. In accordance with their training, emergency responders withheld medical treatment and waited for the cognizant authorities. As a result, the "victim" was declared "dead" before health physics personnel arrived.

This third example convinced us that training at Los Alamos was less than adequate.

II. OFFICIAL GUIDANCE

When faced with a hazard to which one is not trained, the standard procedure is to establish a safety perimeter and wait for the cognizant authorities. While this may be a reasonable procedure if no life is at stake, it is acknowledged that this may not be effective for life saving purposes.

A. FEMA

Consequently, guidelines from FEMA[3] recommend a change in this procedure. The FEMA guidance[3] continues: "The concern addressed by this recommendation is that accident victims may die because of unwillingness to expose responders to a risk that is actually lower than that already taken in simply coming to the accident scene."

B. DOE, EPA, NCRP, ICRP

The US DOE[4], US EPA[5], US NCRP[6], and the ICRP[7] provide general guidance for emergency operations involving ionizing radiation. The guidance from the EPA and DOE is that a dose equivalent of 0.25 Sv (25 rem) to a rescuer is a reasonable risk and is commensurate with a life-saving operation. Personnel may receive more than 0.25 Sv on a voluntary basis if they are fully aware of the risks involved.

C. Los Alamos

In light of this guidance, a training course[8] has been developed and successfully delivered to the Los Alamos Fire Department. The detailed procedures in this course were developed by a committee which included two certified health physicists, a physician assistant, a Battalion Chief from the Los Alamos Fire Department, and representatives from the following Los Alamos National Laboratory (LANL) groups: occupational medicine, fire protection, emergency management and response, hazardous materials response, operational health physics, and radiological safety training. This course has also been endorsed by the LANL Radiological Control Manager.

In an attempt to widen the pool of collective wisdom, we present here a brief summary of the LANL procedures for life-saving in high-contamination and high-radiation situations.

III. PROCEDURES FOR CONTAMINATION

Radioactive contamination is defined as radioactive material in an unwanted place, e.g., a spill of radioactive material from its designed container. The distinction between contamination and radiation is important and familiar to health physics personnel, but not usually understood by emergency responders. For fire-department training, a helpful analogy is: contamination is like smoke; radiation is like the heat from fire. Radiation from fire can kill, but the danger disappears as soon as you leave the scene. Smoke could kill even after you leave the scene, but protection is available by wearing SCBA.

A. Protective Equipment

An emergency responder wearing standard fire department "turnout" (bunker suit) with taped openings and SCBA is well protected from radioactive contamination. With the addition of masking tape to seal all openings, a firefighter in full turnout is as well protected from contamination as a radiological worker in the most stringent level of protective clothing used at the Los Alamos Plutonium Facility. Furthermore, the basic techniques for handling radioactive contamination are easily learned since they are similar to those for other hazardous materials for which fire departments are trained. They are also similar, in principle, to the techniques used by medical personnel for biological hazards.

Specifically, the Los Alamos training emphasizes the following: tape all openings of your protective clothing, wear SCBA, and obtain the assistance of health physics personnel when decontaminating after the emergency. If health physics personnel are not available, radiological personnel at a hospital could substitute temporarily and check for contamination with the standard instruments used with x-ray equipment at a radiology facility.

B. Decontamination

The procedure for dealing with a contaminated victim is known as "strip and ship". Cut off the outer layer of contaminated clothing, strap the patient to a backboard, place a clean sheet on a clean lay-down cloth and wrap the patient in the clean sheet. The team in the contamination area is considered to be the "dirty team". The dirty team hands the patient to a "clean team" for transportation to the hospital. Both teams and the patient are further decontaminated after the emergency, under the careful supervision of health physics personnel.

Intake of radioactive contamination is very unlikely to pose an immediate threat to life or health. On page 63, the IAEA report on Chernobyl[2] states: "the levels of internal contamination were far below those that could significantly contribute to development of acute radiation syndrome (ARS). The ARS which developed in 203 patients was due mostly to external irradiation with gamma and beta rays".

At Chernobyl, the responders did not even wear respirators. In contrast, an emergency responder with SCBA, impermeable protective clothing, and openings sealed with tape is very well protected from intake of contamination. The immediate, life-threatening hazard is from external beta and gamma radiation.

IV. PROCEDURES FOR RADIATION

In the accidents at SL-1 and at Chernobyl, the dose rate was of the order of 10 Gy/h (1000 rad/h). Half an hour in this radiation field is possibly lethal. At a nuclear facility, higher dose rates are possible, which present a life-threatening hazard to both rescuer and victim. Fortunately, radiation can be measured with instruments that are simple, reliable and rugged.

A. Protecting the Responder

Each Los Alamos Fire Department crew is equipped with a portable ion chamber detector capable of measuring dose rates up to 10 Gy/h. In addition, personnel who enter high radiation areas will wear an alarming dosimeter inside their protective clothing. This dosimeter has two distinct alarms with different sounds. One alarm is normally set at a total accumulated dose of 0.2 Gy (20 rad), the other at a dose rate of 2 Gy/h (200 rad/h).

The 0.2 Gy total dose level is to protect the rescuers. Rescuers enter in pairs. If this level is indicated on the dosimeter of either rescuer, both are instructed to leave immediately and allow another team to take over the rescue. In the case of a mass casualty emergency, in which the resources of the rescuers are overwhelmed, a fully informed volunteer is allowed to continue the rescue, up to a maximum total dose of 1 Gy. According to the BEIR-V report[9], the excess risk of death from cancer following an acute dose of 1 Gy is estimated to be 8%.

B. Protecting the Patient

The 2 Gy/h limit is for the benefit of the patient. Below this limit, EMTs will follow the standard procedure, stabilizing the patient and strapping him/her to a backboard before leaving the radiation area in order to minimize the hazard of extrication. Above this limit, the EMTs will perform a rapid extrication to an area of much lower dose rate, in the same manner as used when there is potential for explosions, building collapse, etc. Time should not be taken to fully immobilize the patient prior to moving, though standard manual stabilization should be used if possible.

Every rescue involves uncertain risks. Some of these are as follows. The victim may have back or neck injuries which may be worsened by rapid extrication. On the other hand, the victim has been in the high radiation field for an unknown time before the rescuers arrived. Furthermore, the victim is probably closer to the source of radiation and so probably in a higher radiation field than the rescuer.

Furthermore, the effect of radiation exposure is magnified when the individual is also injured. This is known as the "combined injury effect"[10]. For example, the threshold for a possible lethal exposure drops from approximately 2 Gy to approximately 1 Gy in an individual with serious injuries. Given these uncertainties, the limit of 2 Gy/h was judged to minimize the overall risk to the patient.

C. Extreme Conditions

If the dose rate is off-scale on all available measuring instruments, the rescuers should wait for the cognizant authorities. Although a good argument can be made for an immediate response where the dose rate is about 10 Gy/h or less, in very much higher dose rates the victim is likely to receive a lethal dose of radiation even before the rescue team arrives.

The Los Alamos training[8] includes a procedure for a mass-casualty emergency in which the number of victims exceeds the resources of the rescuers. This emergency may involve rapid extrication to a triage area and establishing a primary treatment area at the scene. However, such extreme emergency situations are unlikely.

V. CONCLUSION

More likely scenarios are comparable to the scenario that introduced this paper, or the exercise discussed in section I.C. In a real, life-threatening situation, we doubt if an EMT would stand by and wait for the cognizant authorities. More likely, some sort of rapid extrication would be performed, perhaps at significant risk to the patient.

At Los Alamos, however, a team from the Los Alamos Fire Department would stabilize the patient, strip and ship, and then hand the patient to a clean team, provided that the dose and dose rate remain below the thresholds in section IV.

Thus, the training developed at Los Alamos represents a change compared with previous training. The study guide[8] contains more details than can be summarized in this paper. Copies of the 136-page study guide may be requested from the authors.

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