

Commentary

Radiological weapons: what type of threat?

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Introduction

Are you ready for a major radiological or nuclear incident, and do you need to be?

Since the end of the Cold War preparations for dealing with major nuclear incidents have declined. Unless a hospital has a nuclear reactor nearby, it is unlikely that radiological incidents will feature high on the major incident plan. Recently, health protection agencies have again started to provide guidance on these issues, following a perceived heightened threat from terrorism [1–3]. The purpose of this article is to demystify the risks and describe the extra actions that should be considered.

The risks of an incident

The risk of a nuclear explosion – the 'nuclear bomb' – is remote; such an incident could either be due to terrorist activity or result from the actions of 'rogue' nation states. However, highly enriched uranium or plutonium can be made into a nuclear explosive device relatively easily. The International Atomic Energy Agency (IAEA) has listed 17 incidents of illicit trafficking of highly enriched uranium or plutonium over the past 10 years [4], and so there is a substantial mass of material that is unaccounted for and thus theoretically available. The risk is therefore present, the numbers of people affected would be substantial, and the potential consequences of any such incident would be great. The incident would present as a massive explosion, with a large blast area and patients presenting with blast and burn injuries.

Overall, the IAEA has recorded 540 incidents of illicit trafficking of nuclear and radioactive materials during the past 10 years, of which the vast majority of cases involved material in the sub-giga-Becquerel range (i.e. unenriched). Although not employable in a nuclear bomb, this material could be utilized in crude radiological dispersion devices – the 'dirty bomb'. However, this remains a rather unlikely scenario. Were it to occur, the health consequences of the radiological

element are likely to be very small. Such a scenario is likely to present as a conventional explosive incident, with casualties presenting with blast and burn injuries. Any radiological element is unlikely to be a feature of the clinical presentation and may be picked up late.

More likely radiological threats to the population arise from accidental releases from energy production installations or research nuclear reactors, or accidents involving vehicles that rely on nuclear propulsion (e.g. satellites coming out of orbit, nuclear submarines, etc.). The highest worldwide risk to individuals is from medicine itself; nearly half of all fatal exposures have been due to calibration errors in equipment used for medical treatment or because of insecure storage of spent radiotherapy sources [5]. These incidents often present with clusters of people with burns without an obvious cause.

The health effects

The perception of the risks to health from radiation does not appear justified by the reality. For example, cohort studies of the 50,000 survivors of the Hiroshima and Nagasaki atomic bombs [6] estimated that only 10% of the 4000 subsequent cancer deaths that occurred between 1950 and 1990 were due to the radiation. Following the accident at Chernobyl there has thus far been no clear excess in leukaemia, congenital abnormalities, or other radiation-associated diseases, although there is evidence of an increase in thyroid cancer [7].

The effect on a person depends on their resistance to the radiation effects; the intensity, duration and type of the radiation; and the chemical characteristics of the material involved. Most clinicians will be aware that iodine accumulates in the thyroid gland and so it affects this gland the most. Few will know that strontium and plutonium accumulate on bone surfaces; plutonium, ruthenium and cerium have particular effects on the lungs; and ruthenium and cerium have effects on the gastrointestinal tract [8]. The types of radiation particles emitted also have an influence on

health. For example, α particles can have a substantial local effect (e.g. on the skin or gastrointestinal tract if ingested) but do not have effects beyond that; β radiation may penetrate a few centimetres; and γ and x-ray radiation may penetrate the whole body, depending on the dose. The types of radiation emitted depend on the radiation source involved. For example, α emitters include radium, radon, uranium and thorium; strontium-90 and tritium emit β radiation; and iodine-131 is a γ emitter. With these provisos, high-dose radiation exposure would have the following early signs and symptoms [5] due to direct cellular death:

1. Nausea, vomiting, weakness and fatigue within hours to days.
2. A falling lymphocyte count starts within hours. The rate of decline is an effective method of quantifying the size of the radiation dose received. The risk of sepsis is highest between the 25th and 35th days.
3. Fever and diarrhoea also occur in this time frame if there have been sufficiently large doses.
4. Following this early phase, infection, bleeding and gastrointestinal symptoms occur.

Ultimately, the diagnosis of radiation sickness is a clinical diagnosis and does not rely on Geiger counters, although these devices may play a role in identifying contamination in the emergency room.

The management of individual patients

The UK National Health Service major incident planning guidance [9] emphasizes that the 'treatment of life-threatening injury should take priority over monitoring or decontamination where there is contamination with a radioactive substance only.' The reason for this is that the risk to staff from radiological contamination on or in a patient is very low indeed. Thus, managing a radiological incident is theoretically much more straightforward than one that may involve biological or chemical agents.

Initial triage of patients should therefore follow advanced trauma life support and major incident guidelines as appropriate [10,11]. The time interval between exposure and vomiting can be useful as a triage tool for those physically uninjured by any blast [5]. If the person vomited within an hour, then they are likely to have received a large dose of radiation and should be managed in a centre with radiopathology expertise. If vomiting occurs 1–2 hours after exposure, then a hospital ward with haematology experience is most appropriate; and if vomiting starts beyond 2 hours then surveillance on a general hospital ward is advised. If the patient does not vomit then outpatient surveillance is acceptable.

In practice, most institutions will not have an initial response sophisticated enough to respond in differing ways to the various nonconventional threats (i.e. biological, chemical, or radiological). Thus, most hospitals will activate a plan that will involve decontaminating walk-in casualties before allowing

them into the emergency department. However, once the initial confusion has settled, active management of the response should remove unnecessary delays in treatment.

Without prejudicing the treatment of traumatic injury, the main specific preventative measure for patients involved in a radiological incident is decontamination. This may have already been done by the emergency services close to the scene (near the 'hot' zone), or may be performed just before casualties enter the hospital. In the case of people with life-threatening conditions this may be delayed until after initial management. The most important element of decontamination is removal of the person's clothes. Where possible casualties should do this for themselves, but they may be assisted by health care staff. Ideally, the health care staff involved in this will wear full protective clothing, but a study has shown that a surgical mask and careful removal of clothes to prevent aerosolization did not lead to contamination of health care workers [3]. The risk of aerosolization can be reduced by gently dampening the clothes before removal, cutting rather than pulling off the clothes, and immediately placing the clothes in a plastic bag and sealing it. The second element of decontamination is a shower, with copious quantities of water. This is particularly challenging in the case of critically ill patients. A thorough wash, using standard precautions, will suffice but decontamination units should have facilities for recumbent casualties.

A further possible specific counter-measure is the issue of stable iodine tablets, which is only of benefit where a release of radioactive iodine has occurred. This is seen with the detonation of nuclear weapons and major accidental release from nuclear reactors. The iodine works by saturating iodine-binding sites in the thyroid before radio-iodine can bind, thus reducing the accumulating radiation exposure to the thyroid. Stable iodine will not prevent any other radiation effects. Health protection organizations will provide advice on this. In the UK there are supplies of stable iodine at nuclear reactor sites and at other locations; other countries have adopted similar public health strategies.

The overall management of a radiological incident

Governments and health protection organizations throughout Europe have plans for such incidents. Depending on the size of the incident, there may be international (e.g. World Health Organization, IAEA, European Union), national, regional and local coordinated responses that rely on the cooperation from many different sectors, including the military, local government, nuclear installations, the emergency services and the health service. Experts will rapidly disseminate information for clinicians tailored to what is known about the exposures. This is likely to evolve over the first few hours after an incident.

As the acute phase of the incident wanes, careful consideration will be given to any further actions required. Depending on the extent and type of radiation, a decision will be made on whether

remediation or semipermanent evacuation is required for the safety of the population [12]. Later on, public health authorities will consider the need for enhanced surveillance, screening services and increased treatment capacity.

The real problem

The risks of a major radiological incident are low, the short-term health consequences from the radiation are likely to be minimal, and the management is relatively straightforward. Nevertheless, challenges would occur, and the main problems that an intensivist would face would be in keeping the intensive care service operating efficiently. With the centre of a city contaminated, transportation systems would potentially be in disarray. Some staff may elect not to come to work or may have been advised to evacuate the area around their homes, in which case they would naturally prefer to care for their families. For those staff intending to work, transport in and out of and around the hospital would be severely affected. Logistic networks would also be impaired, and, given the current enthusiasm for 'just in time' stores management, essential consumables would soon run short. Patients and staff flows around the hospital should be severely curtailed to prevent the spread of low-level contamination.

Thus, the impact on an intensive care service may be more from organizational and logistical disruption in the management of 'normal' patients than from the incident itself. Disruption in community care is likely to lead to more pressure on services from patients with chronic conditions, such as dialysis-dependent renal failure or domiciliary respiratory support [13–15].

Useful steps to take to be prepared

The six key elements of being prepared are as follows:

1. Ensure that staff (and the rest of the hospital) are aware of the need to treat sick patients as normal following a radiological incident. They need reassurance, before the event, that they will be at a low risk if they do this.
2. Consider how the hospital will be able to continue to receive important information from health protection agencies as it becomes available.
3. Ensure the hospital's major incident planners have given thought to patient and staff flows that would minimize any contamination. This should include the routes between the emergency and operating rooms, intensive care and the decontamination facilities.
4. Give prior thought to how many patients you could provide support to in the event of being unable to transport patients to other providers, and have robust expansion plans.
5. Consider how intensive care departments can support the rest of the hospital in providing a seamless high-quality service for everyone throughout a major radiological incident.
6. Anticipate the delivery of service in a logistically chaotic situation.

Conclusion

The risk of a radiological terrorist incident is low. Nevertheless, the working through of such scenarios and the conducting of 'desktop' exercises may prove to be a useful investment in time. Our original question was, do you need to be prepared? The answer is for the individual reader. However, even if a radiological threat is not felt to be an immediate local hazard, many other man-made or natural disaster scenarios would produce similar logistical headaches, and it makes sense for us all to anticipate these.

Interested readers should refer to Farmer and coworkers [16] for more in-depth discussion of the issues considered here.

Competing interests

The author(s) declare that they have no competing interests.

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