J R Army Med Corps 2004; **150**: 3-4

Casualties Resulting From Nuclear Explosion: An Overview

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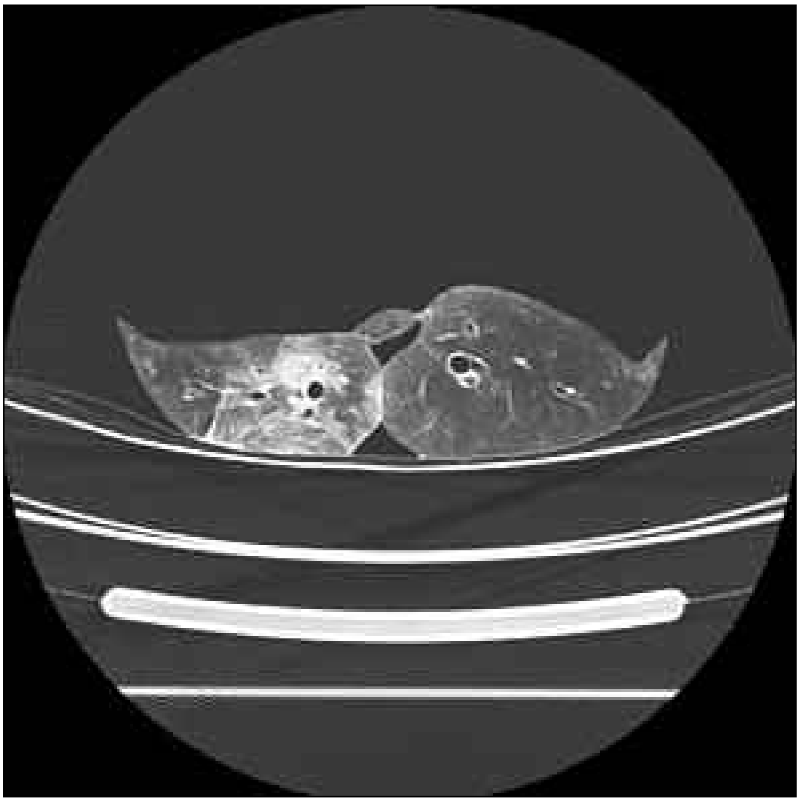
Introduction
This issue of the Journal is devoted to the management of casualties resulting from nuclear explosion. Detonation of a nuclear device results in the release of many forms of energy all of which are potentially damaging to human beings. Like other forms of unconventional weapon, it is the fanatical terrorist that poses the greatest threat of some form of nuclear device being used against an unsuspecting civilian population. However, a nuclear accident, such as that which occurred at Chernobyl, could produce large numbers of casualties from gamma-irradiation without the effects of other forms of energy. This overview introduces all the potential clinical aspects of a nuclear detonation. In the articles which follow, selected aspects of greater clinical importance are considered in greater detail.



Light
A flash of intense light is produced immediately. Indirect light exposure can produce temporary blindness due to chemical transformation of the retinal pigment rhodopsin. Direct light exposure can cause permanent blindness secondary to retinal burns.

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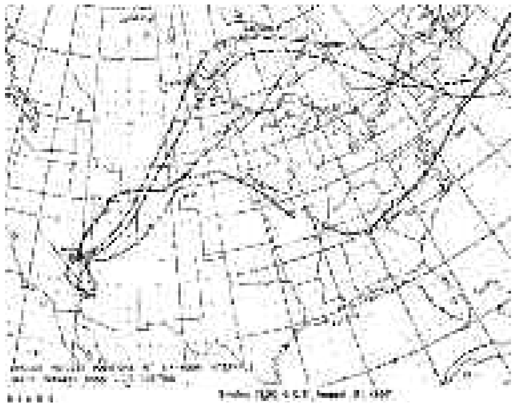
Electro-magnetic pulse
The electro-magnetic pulse may be one factor which produces the neuropraxia following nuclear detonation. This functional defect should recover, at least in the short-term.

Heat
Intense heat may produce vapourisation of human subjects at close proximity to the detonation. Factors such as distance, cover, clothing and relatively reflectant (light) rather than absorbant (dark) coloured clothing will all confer some protection. Burns will be encountered both as a primary effect and secondary to combustion of surrounding flammable materials



Pressure changes
An expanding marked increase in air pressure (blast) will cause a number of injuries including conventional trauma, rupture of tympanic membranes and disruption of membranes at air/fluid interfaces including the pulmonary alveolar capillary membrane. These may result in high permeability pulmonary oedema (adult respiratory distress syndrome) and damage to the lumenal/mucosal interface in the gut causing bacteraemia.

Radiation
Radiation is released at the time of detonation and by the generation of radiation-emitting products of fission. Penetrating ionising radiation, primarily gamma-irradiation, produces dose-dependent effects. The tissues with the lowest threshold for radiation-induced damage are those where the rate of cellular reproduction is the greatest, such as in the bone marrow and the gastro-intestinal mucosa. In all cases, a primary radiation

syndrome, otherwise known as radiation sickness, occurs and consists of malaise, anorexia, nausea and vomiting. This may be followed by recovery and a latent interval before the development of a secondary radiation syndrome. As radiation dose increases so the latent interval may diminish, or disappear altogether, before onset of a secondary radiation syndrome. Congruous with tissue susceptibility, three such syndromes have been identified: haemopoietic, gastro-intestinal and neurovascular syndromes. The latter two syndromes are associated with invariable loss of life, the only distinction between being the increased speed with which this occurs in the case of the neurovascular syndrome.

Hair loss may occur with all three syndromes but, although the cosmetic effect may be distressing, this does not, of itself, have life-threatening effects. It does, however, indicate that a significant radiation dosage has been sustained.

Haemopoietic Syndrome

Lower radiation dosage (<100 cGray) causes a haemopoietic syndrome where variable degrees of pancytopenia occur as a result. Neutropenia may be associated with a reduced threshold for infection, especially when there are coincident conventional injuries. Lymphopenia may result in reduced cell-mediated immunity, such a change may exacerbate a lymphocyte count that is already reduced as a consequence of trauma. Thrombocytopenia may lead to impaired blood clotting such that conventional wounds bleed more readily or spontaneous bleeding occurs (purpura, ecchymoses and gastro-intestinal haemorrhage)

Gastro-intestinal Syndrome

The integrity of the gastro-intestinal mucosa is essential if haemorrhage and spontaneous Gram-negative septicaemia are to be avoided. Mucosal integrity may well have been disrupted already by the pressure wave generated by the nuclear detonation and manifested as early-onset haematemesis and/or melaena. Irradiation will greatly diminish enterocytic reproduction in the mucosal crypts, reducing mucosal thickness while producing immunoparesis as a result of reducing the activity of the gut-associated lymphoid tissue. Loss of immunocompetent cells will prevent antigen recognition and T-cell activation and production and secretion of immunoproteins will cease. The situation will be worsened by leukopenia which further reduces the threshold for spontaneous Gram-negative septicaemia.

Neurovascular

The cells with the lowest reproductive capacity have the highest threshold for adverse affects from ionising radiation. Neurons and endothelial cells fall into this group. Choreo-athetoid movements have been described in experimental animals exposed to radiation. Spontaneous bleeding into tissues will result when vascular permeability is increased following irradiation. There is usually no latent interval between the primary radiation syndrome and the onset of the neurovascular syndrome.

Treatment

Casualties manifesting the haemopoietic syndrome as the sole manifestation of irradiation damage are potentially salvageable. They should be decontaminated of any residual gamma-emitting radio-isotopes by discarding all clothing and showering. Scintillation counter surveillance will indicate the efficacy of this. Reverse barrier nursing to minimise exposure to infective pathogens will help, if available. Blood transfusions may provide immediate help with a pancytopenia. Granulocyte-macrophage colony stimulating factor
may boost neutrophil and platelet counts provided stem-cell responsiveness remains. Prophylactic antibiotics may help to raise the threshold for infection from conventional injury sources and the gastro-intestinal tract. Ultimately, some form of marrow repopulation manoeuvre might be attempted. Bone marrow transplants attempted on those irradiated during the Chernobyl accident were uniformly unsuccessful. However, modern developments may increase the chance of a satisfactory clinical outcome.

Long-term surveillance of survivors

There is an increased risk of carcinogenesis remote from the time of irradiation. Skin and gastro-intestinal cancers are particularly prone to occur. For this reason, survivors require close monitoring if the risk of this complication is to be reduced by early intervention.

Conclusion - The need to maintain knowledge and treatment capability

It has to remain our earnest hope that the Defence Medical Services will never have to deal with casualties from a nuclear incident. However, present times are one of the least politically stable in the history of man and the possibility remains that we could be confronted by such casualties. Those among our number who are particularly keen to work in such areas as haematology, gastroenterology, microbiology and radiation biology should be encouraged to acquire the knowledge and skills to enhance and maintain our military medical capability. Additionally, sources of provision of essential modern medications and treatment facilities need to be identified. Only then will we be prepared if the challenge arises.