ANNEX 3

BIOLOGICAL EFFECTS OF NUCLEAR WAR

ACUTE EFFECTS OF RADIATION; THE LD-50 VALUE

by

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Bases for estimates of LD-50 in man

Whole-body exposure to high doses of radiation gives rise to acute effects, i.e. the prodromal syndrome (radiation sickness), which may manifest itself within hours, or even minutes, after the exposure, and - if the dose is sufficiently large - death within a few weeks.

At high doses, above 10 gray, mortality is 100%, but the time of death is a function of the dose. The general trend of this function, compiled mainly from mammalian data,[1] is shown on Fig. 1. At very high doses death may occur within hours, but with decreasing dose the time of death extends to weeks.

At doses below 10 gray there is a chance of survival, particularly if medical treatment is available. The syndrome causing death in the range 1 to 5 gray is damage to the haemopoietic system (and the relevant dose is therefore that received by the bone marrow). A bone marrow transplant - if not rejected by the body - can prevent death in some cases, but such treatment is most unlikely to be available under war-time conditions. For this reason, even a dose to the bone marrow of less than 5 gray may produce 100% mortality within 60 days after exposure. At lower doses there is an increasing chance of survival. The probability of death is a sigmoid function of the dose. An example of such a function, obtained in experiments with mice, is shown in Fig. 2.

The chief characteristic of such curves is the LD-50 value, that is the dose that causes 50% mortality in a population exposed to it. A remarkable feature of the curve is its steepness, which means that estimates of radiation casualties are very sensitive to the LD-50. As seen from Fig. 2, an error of $\pm$ 30% in the LD-50 value can make all the difference between practically 100% survival and practically 100% mortality. For humans the curve is less steep, but an accurate value of the LD-50 is still necessary for an estimate of casualties.

The problem is that while there are plenty of such data for animals, there are practically none for man. Early data[2] from a group of patients with cancer, which indicated a bone marrow LD-50 of 2.5 gray, were dismissed as not being applicable to the general population. Estimates of the LD-50 in man were based mainly on the very small number of people exposed to large doses of radiation in accidents that have occurred before the Chernobyl disaster. Like in Chernobyl, most of the victims of the earlier accidents received intensive medical treatment, that included barrier nursing, antibiotics, platelet and red blood cell concentrates, and bone marrow transplants.[3] As already mentioned, such treatment enables people to survive much higher doses, nevertheless, it was assumed that this does not affect the LD-50 value. For example, in the United Kingdom an effective LD-50 of 6 gray to bone marrow - deduced mainly from the people exposed to radiation in accidents - is being used to estimate radiation casualties in a nuclear war.[4]

In Hiroshima and Nagasaki a large number of people were exposed to radiation under war-time conditions, but these data have not been utilized because of the alleged difficulty in separating mortalities caused by radiation from those caused by blast or heat.[5] However, recent surveys carried out in Japan in connection with the reassessment of the dosimetry for long-term effects (see Annex 1) provided an opportunity for another look at the acute effects of radiation. Under the auspices of the World Health Organization a survey was carried out on a large number of people in Hiroshima,[6] which provides suitable material for an estimate of radiation casualties under war-time conditions.