ACUTE AND LONG-TERM HEALTH EFFECTS OF RADIATION

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Ionizing radiation is energy in the form of moving particles or electromagnetic waves (Figure 1). These particles or waves carry enough energy to strip off an orbiting electron when they pass close to or hit an atom. This action produces an ion pair--a negative electron and a positive atom or molecule. The affected molecule may be in tissue or in water, which comprises 60% to 70% of tissues. These highly reactive ions immediately recombine with surrounding atoms or molecules.

Ionization is used to measure radiation doses. Radiation dosimetry requires measurement by a device that determines the number of these events that occur in a given volume within a given time. Tissues act as radiation detectors in that the number of ionizing events will determine future effects, which range from molecular effects within cells to effects within populations (Table 1).

The changes described in this paper are those occurring within an organ or whole body and include acute and late health effects. Some are threshold effects (Table 2), which means that the dose must exceed a certain amount before these effects are observed. The severity of the effects correlates directly with the degree of cell damage or with cell death.

A threshold effect is also called a "nonstochastic" effect in the health physics literature. "Stochastic" is a synonym for random; thus, threshold effects are nonrandom events involving cells, organs, and individuals. Some late effects, such as radiation cataracts and teratogenesis, also have dose thresholds.

The late effects of cancer and genetic disturbances are listed as probabilistic or stochastic effects in Table 2. The risks of these events correlate with certain biochemical events within cells rather than with direct cell damage or cell death. The seriousness of the ultimate event is not related to the radiation dose. What is dose related is the probability that a particular health effect will occur.

A number of factors affect the biological effects of radiation exposures (Table 3). Radiation dose is the key factor. As the dose is spread out in time, ie, with a lower dose rate, there is more time for cellular repair to take place. Thus, if the same dose is delivered at a lower rate, the biological effect is less. A similar process occurs with dose fractionation. In radiation therapy, for example, the total dose is given in fractions over a period of weeks.

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