RISK EQUIVALENT OF EXPOSURE VERSUS DOSE OF RADIATION

Victor P. Bond, M.D., Ph.D.

Radiation is perhaps unique among all agents of interest in the Health Sciences in that it alone is both a therapeutic agent for the control of cancer and an essentially ubiquitous environmental agent with a potential for increasing the cancer rate in human populations. Therapy of tumors is accomplished with high-level exposure (HLE) to radiation, ie, large doses are delivered locally and in a controlled fashion in order to effect control or a cure. Thus it conforms to the concepts and approaches of pharmacology, toxicology, and therapeutic medicine. Only one function, that which relates the object-oriented and nonstochastic independent variable organ dose to its effect on a cancer or an organ, is needed to estimate the probability, P_2, of a quantal response. Only P_2 is needed because P_1, that the cancer slated for such treatment will receive some amount of the agent and be affected to some degree, is effectively unity.

The health problem involving low-level exposure (LLE) to radiation, in contrast, is not at all analogous to those of pharmacology, toxicology, and medicine. Rather, it presents a public health problem in that it is a "healthy" population, albeit of cells, that is exposed in a radiation field composed of moving radiation particles with some attendant low-order carcinogenic or mutagenic risk. During exposure, energy is transferred to cells stochastically (ie, through random processes) with respect to which cell is hit and how much energy is transferred rather than in the ordered fashion characteristic of HLE. Under these circumstances the use of dose as an independent variable is proscribed because the amount of stochastically transferred agent is beyond human control. Thus, the concepts, quantities, and terminology applied to low-level radiation must be modified from their present orientation toward pharmacology, toxicology, medicine, and "dose" to conform to those of public health and accident statistics, in which both P_1 and P_2 for the exposed cells must be estimated. The unique opportunity afforded by radiation to develop quantitatively the general relationships between public health and therapeutic medicine is taken advantage of. A principal point I shall make is that the so-called "linear, no-threshold dose-response" curve, characteristic of LLE and accident statistics only and a central pillar in radiation protection philosophy, is not a "dose-response" curve in any sense that a physician, a pharmacologist, or a toxicologist would accept. Rather, neither the "dose" nor the "response" mean the same as do these terms as used in medicine.

The linear no-threshold or proportional relationship is widely used, as is seen in the way in which the values for cancer risk coefficients are expressed--namely, in terms of new cases, per million

---

Senior Scientist, Medical Department, Brookhaven National Laboratory, Upton, New York.