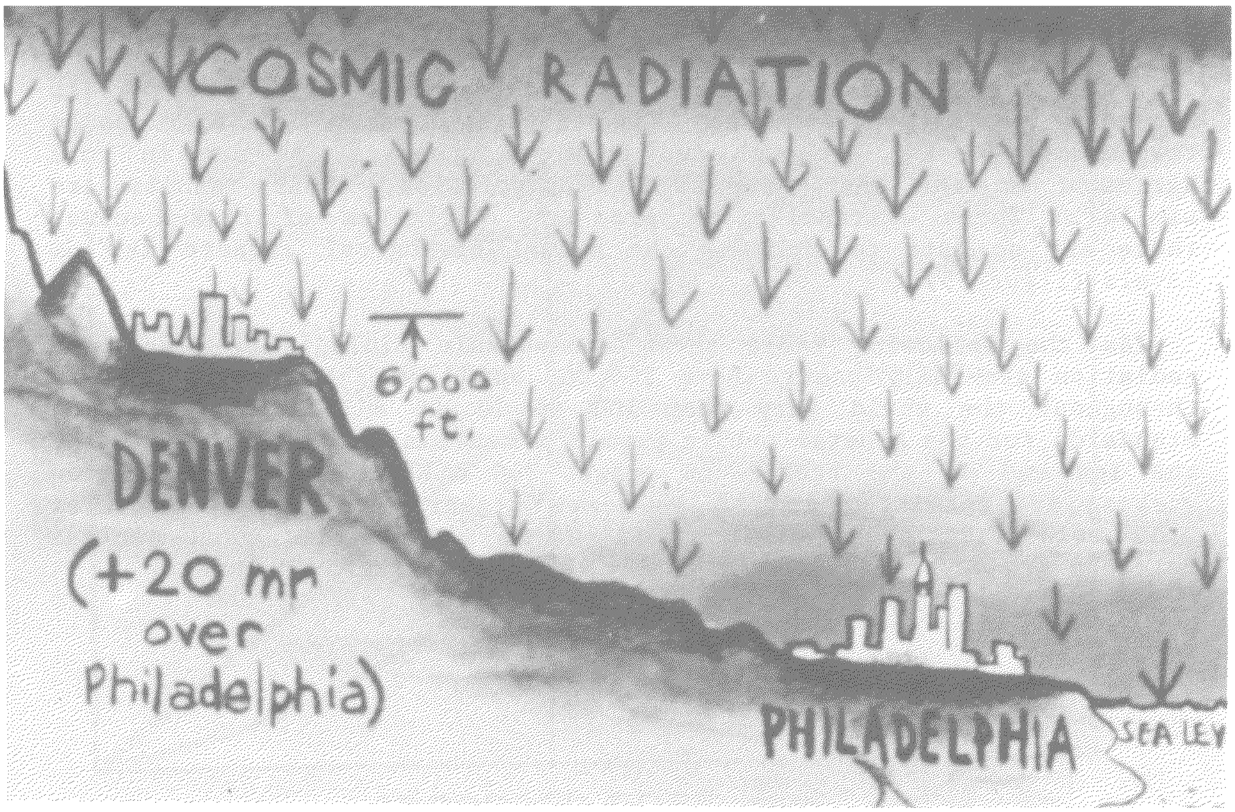

Figure 4. Radiation dose increases with altitude (Courtesy of the American College of Radiology)

Finally, more than 100-fold geographic variations in background radiation have been identified. Near sea level, background radiation in the United States is between 100 and 150 mR per year. Skiing and mountain climbing increase exposures two to three times. Along the west coast of India in the state of Karela, the background level is about ten times that in Washington, D.C., while in one area of Brazil, it is about 100 times higher. These variations should be considered in our assessment of radiation risks whether the issue concerns the practice of medicine or the production of energy.

LOW-LEVEL EXPOSURE

In order to assess the risks of low-level exposures, it is necessary to extrapolate from the effects observed at high doses toward zero dose. Although two previous speakers are not in full agreement on the best method of extrapolation, their results are similar. These extrapolations are only estimates of risk because there are no data to indicate the actual biological effects at low levels (Figure 5).

As the following table shows, measurable biological effects of radiation generally occur above 100,000 millirem. Background levels throughout the world vary from 100 to 10,000 millirem. Radiation standards for the general public permit a maximum whole body dose near the low end of the background range, 500 millirem, while radiation workers are permitted a dose 10 times higher. Potential exposures from television sets, luminous clock or watch dials, and nuclear reactors are several orders of magnitude below background levels.

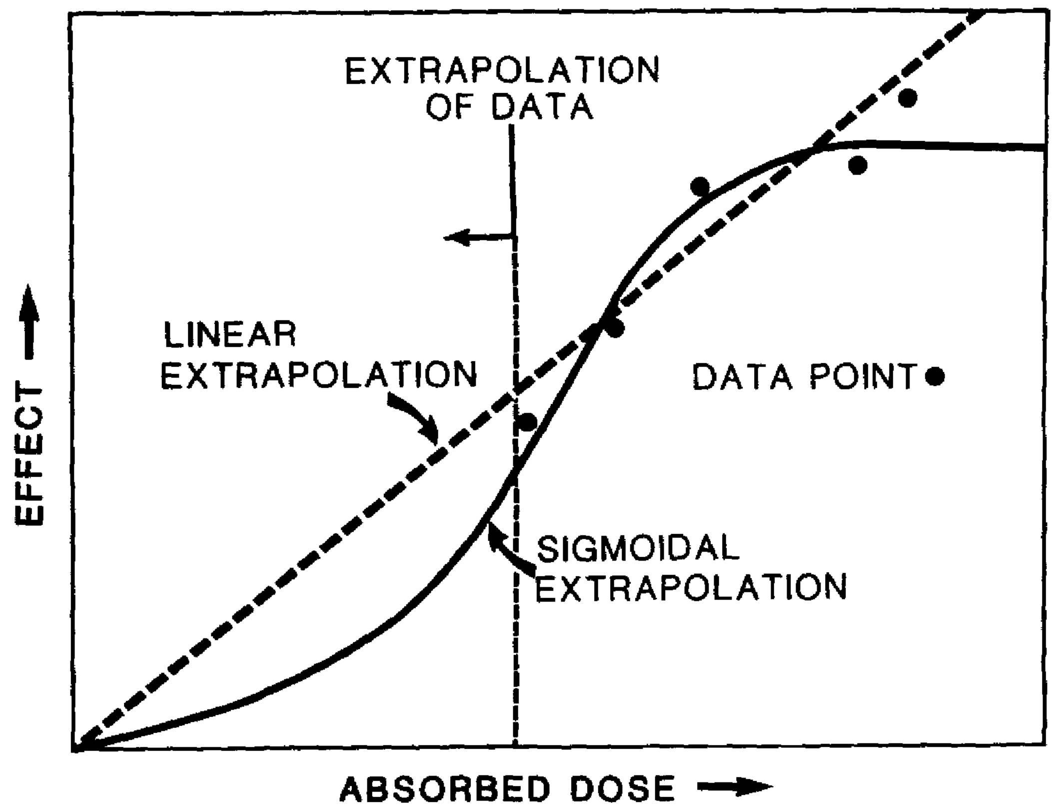

Figure 5. Observed effects of radiation versus absorbed dose. Extrapolation of data to zero dose may be linear or sigmoidal.[1] (Courtesy of CRC Reviews in Diagnostic Imaging)

RADIATION EXPOSURE (Millirems)

Millirems	
1,000,000 – 10,000	Measurable Biological Effects (1)
1,000 – 100	Background (2)/Radiation Standards (2)
100 – 10	Medical (2)
10 – 1	Fallout (2)
0.1	Television, Luminous Dials (2)
0.01	Nuclear Reactors (2)

(1) Acute exposure

(2) Annual dose

Generally, a low dose is a single exposure below 10 rads, or slightly more delivered over many days because there is a certain amount of recovery between repeated doses. It is difficult to determine whether a low dose will cause cancer, because many cases of cancer occur spontaneously in the absence of radiation. The natural incidence of cancer is 33%, and 16% of our population will die from cancer; these percentages far exceed the projected number of radiation-induced deaths from cancer. Furthermore, radiation-induced cancers are not unique and cannot be distinguished from those occurring naturally. The relatively long latent period for cancer induction further complicates the matter. Thus, we may conclude that there is no proof that the incidence of human cancer increases after exposures below about 10 rads.

Likewise, it is reasonable to conclude that it is unlikely that exposures of human fetuses to a few millirads of radiation will cause measurable genetic abnormalities, inasmuch as about 4% of newborn infants have some congenital defect, and any induced effects would be indistinguishable from those that occur spontaneously. The doubling dose for abnormalities in newborn animals of various species has averaged somewhat above 30,000 millirads of acute radiation exposure.

In summary, of a population of one million people, 160,000 are expected to die of cancer. Epidemiologists estimate that the average background radiation in the United States, about 125 millirems per year, could account for less than 2% of these deaths. Each rad received above background could then contribute up to 200 additional cancer deaths per million persons. This is a risk of about 0.001% and is inconsequential compared to other risks in our lives. Or to quote Dr. Rosalyn Yalow, "From the dawn of mankind our progenitors have been exposed to radiation from natural radioactivity in the soil and food as well as from extraterrestrial cosmic rays. Yet the path of evolution has been continuously upward. Surely this experience would suggest that continuous exposure to natural levels of background radiation has not proved deleterious to the human population as a whole."

MISCONCEPTIONS ABOUT RADIATION HAZARDS

Why is there a great concern about ionizing radiation? It exists because radiation is a technically difficult topic, and arguments, though false, continue to infer that low-level radiation causes adverse health effects. The end result is confusion and anxiety.

Emotional and sometimes inaccurate media coverage frequently accentuates misconceptions concerning radiation. Patients are unable to understand whether the risks of a medical radiation procedure outweigh the benefits. Unfortunately, the patient's physician also often knows less than is desirable about the benefits and risks.

The public's misconceptions include:

1. Little is known about the radiation effects, except that even a small amount is extremely dangerous.

2. Anyone exposed to radiation will very likely develop cancer.

3. Medical radiation exposures may be more dangerous than the illness itself.

4. Exposed parents will carry a high risk of genetic abnormalities to their offspring.

Physicians must recognize these misconceptions in order to make objective evaluations.

Another misstatement is, "There is no information about the effects of low doses." As a matter of fact, we have a great deal of negative information that there is no effect at low doses that we can actually measure.

Let me illustrate another misconception that occurred in Minneapolis about 12 years ago: The front page headline in the Minneapolis Tribune read, "Gadler [a member of the Minnesota Pollution Control Agency] Shuns Ride with Radioactive Cargo." Mr. Gadler had gone to Michigan to testify in opposition to the commissioning of a nuclear power plant there; on his return through Chicago he changed planes and asked to see the manifest for his scheduled flight to Minneapolis. The manifest listed a package containing a radioactive material, so he asked that the package be removed or he would not board the airplane. He said, "I don't like it, it can kill you and I am certainly not going to fly around in the air with it."

As a result of all this furor, when he arrived at the Minneapolis airport, he was met by a newspaper reporter. I decided to check the validity of the story that appeared in the Tribune and found that the package in question contained only a few microcuries of a beta-emitting radionuclide. No radiation level above background was detectable outside the package. I then spoke to the reporter and asked that he set the record straight and volunteered to work with him on an article that was factual. He refused. Some days later a Letter to the Editor appeared in which the writer stated that he was disappointed in a member of the Minnesota Pollution Control Agency who did not understand radiation. He suggested that if Mr. Gadler was really concerned he ought not to fly in an airplane. The writer ended his letter by saying, "I would still further question the advisability of making prominent news out of such nuclear scare stories. It is time for a responsible press to consider the consequences of misinforming or aiding in misinforming the public." This is the issue before us.

PLANNING FOR RADIATION EMERGENCIES

We have heard repeatedly during this conference the importance of every physician truly understanding the medical and industrial uses of radiation. Unfortunately, possessing an M.D. degree does not necessarily mean that we have all the right answers. We hope that we all can and will maintain a positive slope to our learning curves and gain an adequate knowledge of the basics of radiation biology. A significant number of physicians are wedded to the concept of "no nukes." I am in total agreement with their mission to prevent the horrors of a nuclear war. However, we must oppose the actions of this group when all day-to-day beneficial uses of radioactivity are folded together with the spector of nuclear war.

As physicians, we must appreciate the world's energy needs and consider how best they can be met, including the use of nuclear power. We should understand radiation regulations, as well as the basics of lifesaving measures in radiation emergencies. Radiation monitoring might be a part of our responsibility, although physicists and environmental engineers usually are available for such matters. Plans must provide for collecting body fluids of exposed individuals and other data useful for an assessment of exposure and for arrangements to transfer victims to special care units.

Among the registration materials you received at this conference is, "What the General Practitioner (M.D.) Should Know About Medical Handling of Overexposed Individuals" (IAEA TECDOC-366, 1986). This points out that information on radiation emergency medical planning should include methods for determining the extent of exposure and materials on decontamination measures, techniques for reverse isolation (for those who are likely to become leukopenic), administration of potassium iodide, and other extraordinary medical and surgical procedures.

Emergency medical planning for a nuclear power installation should include procedures for preventing an incident from becoming an emergency as well as for measures to be taken if an emergency does occur. A nuclear power plant is required to have a medical triage plan and an established program of emergency medical care with a local hospital; the plant should establish an agreement with a definitive care center that can dispatch a Radiation Emergency Medical (REM) team to the site immediately if the situation warrants. The nuclear plant also may provide consultation by telephone or in person and be able to analyze body fluids and other samples for an assessment of exposure. It is also very important to maintain an alert status, which includes periodic training and exercises for personnel and frequent audits of the emergency measures and equipment.

There is a need for guidelines in emergency planning for nuclear installations throughout the world. These plans should include a full and immediate disclosure of all radiation releases and exposures. As has already been mentioned, access to emergency medical care in a hospital designated for this purpose is necessary. These guidelines, together with other pertinent information and data, should be made available to medical societies and medical groups to assist them in educating themselves as well as the public about the risks of radiation.

BENEFITS VERSUS RISKS

Now to address briefly the matter of radiation exposure from the standpoint of benefit versus risk. The risks include cancer induction, genetic abnormalities, and shortening of life. In addition, the disposal of low level radioactive waste carries with it some risk.

The most feared of all is nuclear war, which we hope will never happen. In terms of equivalent risks, a nuclear medicine brain scan is equivalent to 18 chest radiographs, one small bowel x-ray, smoking three packs of cigarettes, eating ten pieces of pie a la mode, or living for three years in Denver as opposed to living at sea level.

So what about the benefits? There are indeed many benefits derived from radiation exposure. These include the uses of (1) x-rays and radioactive tracers for medical diagnoses, (2) radiation for cancer treatment, (3) radioactive materials in medical and industrial research, (4) radioactive tracers in various manufacturing processes, (5) radiation of food for preservation, and (6) nuclear power for energy production.

Physicians must appreciate the relative benefits that are associated with all forms of energy production. Until the Chernobyl accident, the nuclear power industry had an enviable record of safety--no fatalities--compared to either oil- or coal-fired power plants, which have recorded many deaths. Despite the Chernobyl accident, nuclear power generation is by far the safest means of producing energy to meet the world's needs.

What have we learned from the TMI accident? Certainly not as much as we could or should have as far as providing emergency care to radiation victims at or near the Chernobyl plant. This may have been due in part to the major differences in reactor designs, as well as to vast differences in the magnitude of these accidents. However, the inability to learn from such experiences and the failure to communicate what has been learned are factors that must be borne in mind for the future. Recall the tremendous alarm expressed by the media. For the most part the media handled the facts concerning Chernobyl appropriately. However, there were a few notable exceptions.

Two quotes from a presentation by the Lord Marshall of Goring at a recent international meeting illustrate very nicely the situation in which we find ourselves. (1) "Within the next half century or so we must either keep the Third World short of energy and in poverty so that we in the West can retain a disproportionate share of the world's energy (oil), or we must introduce and develop a new energy source (nuclear power)." (2) "The public must accept nuclear power because they understand it - not because it is risk free - but because it has the smallest risk of any energy source known to man."

In conclusion, let us ask, "What is the net result of the judicious uses of radiation on the health and quality of life?" I believe the answer is contained in Figure 6 in which I have related health of the world's population to radiation exposure. Through judicious use of radiation in research, industry, and the practice of medicine, there will be continued significant improvements in the quality of our lives and our health. There is little question in my mind but that we are operating on the positive slope of this curve and will continue to do so in the future.

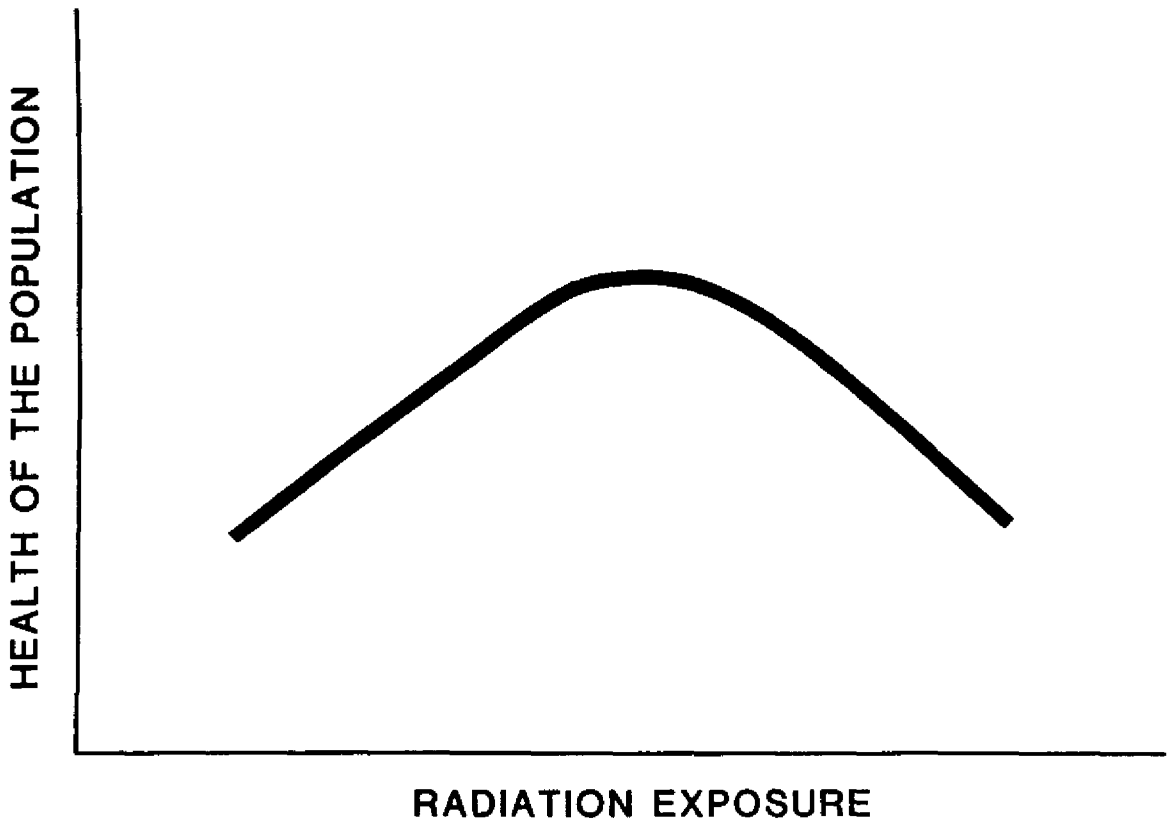

Figure 6. Expected relationship between radiation exposures to humans from various sources and the overall health of the population from these exposures.[1] (Courtesy of CRC Reviews in Diagnostic Imaging)

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