Scientifically Speaking

Low-dose radiation

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Washington, DC—It didn't take just a malfunctioning nuclear power plant in Pennsylvania to alarm United States health officials about the potential dangers of low-level ionising radiation. The near-disaster at the Three Mile Island facility close to Harrisburg simply capped a winter's growing discontent on the part of both the public and scientists over seemingly risky nuclear practices and the lack of a clear definition of what the risks might be.

Mounting discontent

In the past several months, one report after another has heightened public anxiety about low-level radiation. Part of the difficulty is that scientists can be seen to disagree openly over the meaning of a collection of data. Another part is that some deception by Government can be discerned in its handling of earlier nuclear ventures, such as weapons tests in which soldiers participated. And, of course, foreboding must certainly accompany any events whose most likely adverse health effect is that most feared of diseases, cancer.

Since 1974 at least 10 committees or subcommittees of Congress have taken up one or another concern about low-level radiation. That was the count before the Pennsylvania mishap; there's no telling how many congressional hearings will be inspired by it. In May 1978 a presidential directive ordered the Department of Health, Education, and Welfare to co-ordinate an interagency assessment of research on radiation exposure, public information on radiation, benefits available to people harmed by radiation, and ways to reduce radiation exposure. The summaries of the work groups in that task force were made public at the end of February this year. Although they reviewed much of what Government has collected in the way of information about radiation, the task force concluded that "existing knowledge is insufficient to provide an unequivocal answer to the low-dose question."

Low dose, in the lexicon of the task force, is an exposure to less than 5 rems a year. Rem (for roentgen equivalent man) is the unit that describes a certain amount of biologic effect of radiation. Another unit, rad (for radiation absorbed dose) is comparable to a rem for radiation that has a low linear energy transfer, such as an *x*-ray film. But for radiation with high linear energy transfer, such as fast neutrons, the biologic effects are so much greater that each rad would translate into 10 or more rems. With any luck, most people don't encounter even 1 rem a year, so most exposures, dosages, and even accidental releases of radiation are stated in thousandths of that, millirems (mrems). An average chest *x*-ray examination in the US delivers about 25 mrems.

Some occupations, however—such as those of nuclear power plant employees—have higher exposures than would be permissible for the general public. Government regulations in the US establish a maximum occupational exposure of 5000 mrems a year, which is 5 rems and the upper limit of "low dose." For the general population, the maximum permissible exposure is 500 mrems. These limits, which have been in effect for years, were arrived at largely on the basis of studies of survivors of the nuclear bomb blast at Hiroshima and of recipients of therapeutically intended *x*-ray doses delivered to inflamed tonsils and itching scalps—the latter, of *Tinea capitis* sufferers. Presumably that kind of treatment is not offered much any more, but it had its enthusiastic proponents in the days before most patients had cause to hear dark things about radiation.

From those early studies, there was no compelling reason to disbelieve in a threshold for the biological effects of radiation a dose below which there was no discernible harm to a person. In 1972, however, the National Academy of Sciences issued a report, *Biological Effects of Ionizing Radiation* (the BEIR report), whose data tended to support the validity of a linear extrapolation for dose and effect that there was no dose of radiation small enough to be harmless.

Plotted as radiation dose along the abscissa and cancer incidence on the ordinate, the linear extrapolation downward from radiation doses high enough to kill cells is a straight line to zero dose/zero cancer. But another school of thought likes the "linear quadratic" extrapolation, which makes the line sag to indicate proportionately lower cancer incidence at low doses of radiation, partly because cells are believed to be more able to repair the radiation damage to their genetic material if they haven't been so strongly zapped.

Risks of exposure

Some more recent studies, however, have furnished arguing points that suggest that the line on the graph should balloon rather than sag—that the linear hypothesis underestimates rather than overestimates the risk of cancer from radiation exposure. These studies were treated briefly in the task force summaries released in February, and were the subject of testimony in hearings before a House of Representatives subcommittee in the spring of 1978. As the task force summaries acknowledge, "These studies have been extremely controversial . . . [and] the results, some quite preliminary, have been extensively criticised and vigorously defended. Some results suggest that the linear hypothesis, rather than being conservative, may underestimate the risk of cancer from radiation exposure by a factor of ten or more."

One such study was begun in 1964 under a contract from the old Atomic Energy Commission. It is the longest and largest

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investigation yet of low-level radiation health effects on man, covering 35 000 erstwhile or present employees of the nuclear processing and waste-storage facility at Hanford, Washington, and 112 000 workers at three facilities in Tennessee connected with the Oak Ridge uranium enrichment process. Leaving aside the squabbling that study has caused because of possible embarrassment to one or another Government agency, one of its findings was that about 6% of cancer deaths among Hanford employees could be attributed to low-level radiation. Calculations of the cumulative dose required to double the incidence of cancer ran almost as low as 4 rads for multiple myeloma and 14 to 15 rads for cancer of lung, colon, and pancreas. If those calculations are correct and you can start an argument in dozens of laboratories and offices with that premise it puts a cancer-causing dose of low-level radiation down into the category of dose now permissible as an occupational exposure.

Other studies that may belie the old extrapolations from Hiroshima include an investigation of leukaemia incidence among soldiers manoeuvering around a 1957 nuclear bomb test, whose incomplete results show eight cases when fewer than four would be expected, and a cause-of-death inventory of former workers in a shipyard that repairs and refuels nuclear submarines, which suggested excess deaths among employees exposed to radiation. Neither of those investigations, however, could reliably determine doses to individuals or subsequent insults the subjects could have incurred. The fourth study mentioned in the task force summaries brings up a different source of exposure. It is a survey of diagnostic *x*-ray dosage of sample populations in three states and their subsequent incidence of leukaemia. It estimates the risk to be about 10 time sgreater than earlier studies had suggested. It also raises many hackles.

Medical exposure to radiation is something most of us can more readily relate to than occupational exposure. Perhaps 60% of Americans have at least one medical or dental *x*-ray exposure a year. Government figures blame medical and dental diagnostic *x*-ray films for 45% of the population's entire radiation exposure in a year—which is to say, 18·1 million "person-rems" a year. Half all exposure is natural background cosmic rays, radioactive disintegrations in surface rock, and the like and the remaining 5% results from occupational exposure and weapons tests.

These sources of exposure are, of course, averages. People in the mile-high city of Denver receive more natural background radiation than those in water-level New Orleans. And perhaps those around the Three Mile Island plant in Pennsylvania have received more unnatural radiation than if they had worked and lived somewhere else.

Trouble in Pennsylvania

Assuming that plant workers and nearby residents in Pennsylvania could be exposed to radioactive iodine if the plant were to release more debris, the Federal Government sent 240 000 vials of potassium iodide to the area. US officials urged that workers in all 225 plants take it as a thyroid uptake blocking agent, and also advised that it be distributed free of charge to the 130 000 people who live within 10 miles of the plant. Neither the power company, which runs the plant, nor the governor of Pennsylvania had accepted the potassium iodide offer 10 days after the first sign of trouble at Three Mile Island. Earlier, however, the governor had advised mothers and infants to leave the area, and had closed 52 schools around the plant.

For plant workers, radiation possibilities and actualities of the reactor's threatened melt-down were plentiful. The power company announced that four employees received doses of 3 to 4 rems over a short time, and emphasised that those were within permissible limits. For residents in the vicinity of the reactor, possible low-level dosages are harder to pin down. Government monitoring devices were not in place until four days after the trouble began. The power company's permanent monitoring devices indicated exposures of as much as 2·76 mrems an hour during a time when the plant was venting radioactive gases (which may have continued for 48 hours). The government says that five-day exposure for persons in the vicinity probably did not exceed 80 mrems.

At any rate, the people around Three Mile Island are going to provide the first big prospective low-level radiation study population that scientists have ever had. The department of HEW says it will embark on long-term health studies of plant workers, pregnant women and their offspring, and a sample of the general population exposed to the plant's fulminations. In 20 to 30 years, which is the believed latency period for radiation-induced cancers, a near-calamity may have helped to establish a biomedical truth, complete with classically reproducible results. But it wasn't a source of low-level exposure than anyone would care to reproduce.

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What treatment is advised for recurrent deep-vein thrombosis of the calf with varicose veins and irritable skin?

The first consideration in dealing with *recurrent* deep-vein thrombosis is to exclude any underlying cause of the thrombosis. Has the patient a pelvic mass, such as an ovarian cyst, that might cause pressure on the iliac veins? Is there a carcinoma of the prostate? Is there some haematological lesion, such as polycythaemia? Obviously detailed examination and assessment of the patient are mandatory.

In the absence of any obvious cause for the thrombosis, firm and continued elastic support using elastic stockings is essential. Once the elastic stockings have been fitted, plenty of walking is excellent to encourage the calf muscle pump activity. When the patient is at rest, however, oedema must be controlled by raising the legs. The patient should therefore sleep with the legs well raised on pillows or with the foot of the bed raised. He should get into the habit of keeping the feet above the knees and the knees above the hips when sitting down at leisure. Many of these patients are overweight, often quite grossly so, and this should be treated vigorously.

The associated secondary varicose veins, if confined to the region of the knee and below, are treated by sclerotherapy using the technique which has been popularised and well described by Fegan.[1] Large varices, extending to the mid-thigh or groin, need surgical disconnection at the saphenofemoral junction. Trauma to the legs should be carefully avoided since a trivial injury may precipitate ulceration of the thin, glossy, often pigmented skin associated with the post-thrombotic leg. Should an ulcer be present, the same regimen is adopted but support needs to be even more vigorous using Elastoplast bandaging. The ulcer is protected by means of a piece of sterile gauze and the skin itself shielded from the strapping (to which so many patients are sensitive) either by a simple gauze bandage or by one of the various proprietary impregnated bandages. Once the ulcer has healed, elastic stocking support can be substituted for the Elastoplast bandaging.

[1] Fegan, G, *Varicose Veins, Compression Sclerotherapy*. London, Heinemann, 1967.

Is there any evidence that people who have had a vasectomy are more liable to develop atheroma?

The belief that vasectomy may result in an increase in atheroma is based on animal experiments. Vasectomised monkeys fed on high cholesterol diets developed considerably more atheroma within a few months of operation than did control animals. The damage may be due to antisperm antibodies adhering to vessel walls or to a relative deficiency of testosterone, which has protective effects on heart and blood vessels. So far an increased risk of atheroma from vasectomy has not been shown in man.