civil defense Technical Bulletin

Appendix 8

TB - 11 - 24
July 1956
(Reprinted October 1958)
RADIOLOGICAL DEFENSE SERIES

A DIGEST OF TECHNICAL INFORMATION

MEDICAL ASPECTS OF NUCLEAR RADIATION

This is one of a series of technical bulletins on radiological defense. It presents, in general terms, the medical aspects of radiological defense.

The initial radiation hazard from a nuclear weapon detonated high in the air is due to gamma rays and neutrons liberated at the time of the explosion, and gamma rays from the ascending cloud. Casualties from a low yield weapon burst high in the air, will be from blast, heat, and initial nuclear radiation.

With high yield weapons the relative hazard of initial radiation is greatly reduced because the area covered by the blast and heat effects is larger than that covered by initial radiation. These weapons detonated near the surface of the earth cause great amounts of material to be drawn up into the fireball. This material is contaminated by radioactive products of the bomb. The radioactive particles will fall out causing contamination which may be lethal over thousands of square miles. Under these circumstances radiation casualties may equal or exceed those from blast and heat.

The hazards from fallout radiation are whole-body penetrating radiation, skin contamination, and internal absorption of radioactive materials. The whole-body penetration is almost entirely gamma since there are no neutrons present. In skin contamination, the greatest part of the dose is due to the beta component since the beta particles are absorbed almost entirely in the layers of the skin. The internal radiation hazard results from entry of radioactive substances into the body by breathing, swallowing, or through breaks in the skin. These substances may emit beta and gamma radiation from the fission products and alpha particles from unfissioned material. Inhalation will not be significant unless the particle size is very small—0.5 to 5 microns in diameter. Ingestion and entry through wounds is not so dependent on particle size.

Radiation damage from ingested materials results from irradiation of the body—principally the gastrointestinal tract, thyroid gland, and bone—from fallout particles in the intestinal tract, and radioactive materials absorbed and remaining in the body. It is improbable that there would be enough material inhaled or swallowed during the first few days to contribute appreciably to the acute clinical problem. Chronic exposure will be discussed later.

The Acute Radiation Syndrome

The most reliable means of estimating the seriousness of radiation injury is by the physician's evaluation of clinical symptoms, particularly on the day of exposure. The gastrointestinal tract is one of the most radiosensitive organ systems. Observable functional changes occur promptly after the damage has taken place. The incidence, severity, and time of beginning of vomiting and diarrhea have been shown to be a good index of the degree of radiation damage. Information on the distance from the explosion, amount of shielding present, and amount of radiation indicated by dosimeters should be taken into consideration when estimating total exposure.

On the basis of the severity and time of occurrence of gastrointestinal symptoms, casualties may be divided into three groups:

Group I—*Survival improbable.* These will have received supralethal amounts of radiation, probably in excess of 800 r[1] gamma dose of whole body irradiation, in a short period. Severe, and more or less continuous, vomiting will occur within a few hours, and will be followed by diarrhea, producing severe dehydration and apathy. Death may be expected to occur at any time from one day to two weeks.

Group II—*Survival questionable.* These will have received a dose of probably 200 r to 800 r. Vomiting will occur on the first day, but will subside within about 24 hours to be followed by a period of relative well-being from one to three weeks. This quiescent period may be followed by the development of small subcutaneous hemorrhages, sore mouth and throat, loss of hair, bloody diarrhea, loss of weight, and infection of thermal burns and other wounds which had been healing. Most of these symptoms are common to a variety of diseases, but the occurrence of hemorrhagic spots and falling hair are strongly suggestive of severe radiation injury.

[1] Roentgen (r).—A unit of radiation quantity, defined as that amount of X- or gamma radiation which produces one electrostatic unit of charge of either sign in one cubic centimeter of air at standard temperature and pressure.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF CIVIL AND DEFENSE MOBILIZATION

Group III—*Survival probable.* These will have received a dose probably less than 200 r. No symptoms are to be expected on the first day except transient nausea, some vomiting, and fatigue. Later on, from the second to fourth week, there may be a slight feeling of ill health, but no incapacity will occur in most cases.

It is obvious that it is the Group II patients who will benefit most from treatment. If thermal burns or other injuries are present, the prognosis must be looked upon with more concern.

Blood changes provide valuable information on dosage. In Group I cases there will be a profound and prompt drop in the number of white blood cells. Blood concentration may be marked due to excessive fluid loss and lowered fluid intake. However, gastrointestinal symptoms will far overshadow the blood picture.

It is Group II and III cases in which the blood picture is of great medical importance. Doses in the range of 200 r to 800 r will result in profound drop within a day or two in certain of the white blood cells. Other white blood cells are reduced in number within a week or two. The red blood cells and platelets are also depressed, and profound anemia may occur. Examination of the white blood cells soon after exposure in the low dose range is a valuable aid to diagnosis. The platelet count is correlated with the dose, and if made properly is very helpful in making the prognosis.

The acute radiation syndrome presents no new features that are not observed daily in clinical practice. The diarrhea, dehydration, electrolyte imbalance, hemorrhage, anemia, and infection, are all commonplace findings, and the exercise of sound clinical judgment and good nursing care in the treatment of various aspects of the syndrome will save many lives and hasten convalescence.

Gastrointestinal symptoms should receive careful attention. Straining associated with diarrhea may be treated with antispasmodics such as atropine. Dehydration and electrolyte imbalance should be vigorously combatted with intravenous fluids and fluids by rectum if conditions permit. A bland, soft, or liquid high-caloric diet with vitamin supplements and ample fluids should be given as tolerated. Careful attention must be given to oral hygiene.

The treatment of infections associated with radiation injury is one of the most important aspects of handling these cases. The use of antibiotics presents a problem because early prophylactic use may result in development of resistant strains of organisms when at a later time antibiotics are urgently needed. Vigorous use of antibiotics should be started immediately on development of clinical evidence of either localized or generalized infection. It is advisable to use broad spectrum antibiotics with alternating schedules.

Blood transfusions should not be given as a routine measure, but may be lifesaving when clinically indicated.

Many substances have been tested in the hope of developing a specific preventive or therapeutic agent. To date none has been sufficiently established to warrent its inclusion in the physician's armamentarium, but research continues with the hope that a specific therapy will be discovered and developed to allow a greater number of cases to recover, and the illness to be shortened.

Skin Lesions

A wide variety of skin lesions may develop, depending upon variable physical as well as biological factors. The more important physical factors are:

(*a*) The earlier the contamination after the explosion, the greater the dose for a given amount of fallout material.

(*b*) The longer radioactive material remains on the skin, the greater the dose.

(*c*) The greater the proportion of high energy beta radiation, the deeper the effect.

(*d*) The distribution of material on the skin will determine the location of the lesions.

Among the biological factors are:

(*a*) Areas of the body covered by thinner skin will be more severely affected.

(*b*) Where the hair is thicker, the material will tend to remain longer, and the effect will be more pronounced.

(*c*) The material tends to collect and remain in areas of greater perspiration.

Preventive measures such as taking shelter or keeping indoors during the time fallout is taking place, or covering as much of the body as possible followed by removing outer clothing and washing exposed parts of the body, may completely eliminate or greatly reduce incidence and severity of skin lesions.

During the first few weeks after exposure, there may be no indications of skin damage. In more severe exposures symptoms will occur within the first 24 to 48 hours. These will include: itching, burning or tingling sensations, and burning and watering of the eyes. Areas of redness, swelling, or blanching may be noticed. The greater the exposure, the earlier the symptoms will appear.

Within a few days early symptoms temporarily subside or disappear. The length of time before lesions develop is related roughly to the severity of exposure, and may vary from a few days following severe exposure to a few weeks after a mild exposure.

Following this period of quiescence there is a recurrence or intensification of symptoms. Lesions are usually absent on areas protected by even the scantiest of clothing. They are more likely to appear on areas where the skin is thin, moist, or hairy—head, neck, armpits, and elbows. New lesions may appear over several weeks.

Reddening of the skin, spots, pimples, or raised plaques or tanning of the skin may be the first indication of damage. These lesions may coalesce and form dry, thickened, pigmented areas. Itching, burning, and mild pain may be experienced. Milder lesions may merely show dry scaling from the center outward, leaving a depigmented thinned skin, followed within a few weeks by healing and repigmentation. More severe lesions may show deep destruction with raw, weeping ulcers. Secondary infection may occur especially if there is damage to blood cells incident to gamma radiation and if lesions do not receive proper care. These deeper lesions may be quite painful with resulting limitation of motion. The healing process may be slow or incomplete.

Loss of hair begins 2 to 3 weeks after exposure and usually involves the scalp. Eyebrows, eyelashes, axillary, and pubic hair appear to be more resistant. Unless the exposure has been severe, complete regrowth with normal color and texture within 5 to 6 months, is to be expected.

Treatment during the acute stage is very similar to the treatment of thermal burns. Mild lesions require daily cleansing with soap and water and application of bland ointments or lotions such as calomine lotion with 1% phenol. Ulcerating lesions should be kept cleaned and dressed. Antibiotics orally, locally, or by injection should be used if secondary infection occurs, or prophylactically if there has been a high dose of gamma radiation and severe leukopenia is present. Surgical treatment may be necessary and early skin grafting may be considered in the most severe cases.

Late Effects

Late effects are those harmful results which do not interfere with working efficiency during the first few weeks after exposure. They should never be thought of lightly and

may be a major consideration in postattack and recovery periods. During the attack phase, however, we will be much more concerned with problems of our immediate survival and decisions on permissible radiation exposure will be made accordingly. Except for cataract development from neutron exposure and skin cancer from local radiation damage, late results from single exposures are not qualitatively different from those due to chronic exposure.

Chronic Radiation Injury

Chronic injury may result from one or a combination of the following types of exposure:

(*a*) Continuous low level exposure to external sources.

(*b*) Intermittent exposure to external sources.

(*c*) Prolonged exposure to internal sources.

There is no human and very little animal experience in continuous low level exposure to radiation from external sources. There is, however, much information on long continued intermittent exposure, and little reason to doubt that the clinical picture would be indistinguishable, one from the other. The principal findings are blood changes with leukemia predominating, skin cancer, as noted on the hands and face of radiologists, and shortening the life span—statistically demonstrable in animals and man. There will also be some genetic changes.

Prolonged exposure to internal sources may occur through continued inhalation or ingestion of radioactive substances or the fixation of long lived radioisotopes in the body. Certain substances, such as radium, plutonium, and strontium, have a tendency to become a part of the chemical structure of bones and remain in the body for many years. It is with these substances—principally radium—that we have had most of our experience with chronic internal source radiation injury. The principal results are bone destruction and bone cancer occurring some 20 years after deposition of the radioactive substance. Anemia may occur within a few years after rather large amounts of radium have gained access to the body, but in lower doses—10 to 30 micrograms—it is not a prominent finding.

REFERENCES

Blast Damage from Nuclear Weapons of Larger Sizes, TB-8-1, Feb. 1955.

Construction of Fallout Plots from Coded Messages, Provided by the U. S. Weather Bureau, AB-188, May 25, 1955, Supplement No. 1, August 1955, Supplement No. 2, September 1955.

Effects of Atomic Weapons (Revised September 1950), A. E. C.

Emergency Exposures to Nuclear Radiation, TB-11-1, 1952.

Fallout and the Winds, TB-11-21, Rad. Def. Series, revised Feb. 1956.

Permissible Emergency Levels of Radioactivity in Water and Food, TB-11-8, 1952.

Protection Against Fallout Radiation, TB-11-19, 1955, Radiological Defense Series.

Radiation Physics and Bomb Phenomenology, TB-11-22, revised July 1956.

Radiological Decontamination in Civil Defense, TM-11-6, 1952.

Radiological Instruments for Civil Defense, TB-11-20, Rad. Def. Series, September 1955.

Report by the U. S. Atomic Energy Commission on the Effects of High-Yield Nuclear Explosions, AEC, 1955.

Family Shelters For Protection Against Radioactive Fallout, TB-5-3, 1958.

For sale by the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C.—Price 5 cents.

GPO 815721