Preventing Injury From Radiation

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INJURY from ionizing radiation is a phenomenon which, with the advent of nuclear physics, has squarely challenged practitioners of preventive medicine. The everyday uses of ionizing radiation from various natural and man-made emitters can result in low-level, chronic exposure, if not in inadvertent high-level exposure. Exposure to doses well below dramatic levels can result in slowly developing and currently irreversible adverse biological effects in present and future generations. At this time, virtually the only approach to limiting this potential toll is through preventive medicine. After-the-fact therapy is not now promising (*1*).

Rather than present an abstract, general discussion of radiation control, I should like to describe the policies and practices of the Army Surgeon General and his staff, which are applied daily throughout the world. The Army is keenly aware of the activities and contributions of other agencies and works closely with them. The Atomic Energy Commission, always a leader in this field, provides us with much information and guidance, and there are many projects that are joint endeavors of AEC and the Armed Forces. In addition, the National Bureau of Standards and the National Research Council, as well as other agencies, play important roles.

Early Medical Concern

The Army's concern with the problem of radiation injury is based on medical history since Roentgen discovered X-rays in 1895, Becquerel discovered natural radioactivity in 1896, and the Curies isolated polonium and radium in 1897–98. That the potentially harmful effects of radiation were suspected early is borne out by the following quotation from American Martyrs to Science Through the Roentgen Rays (*2*): "Within a period of 90 days after Roentgen's 'Preliminary Communication,' suspicion was aroused in the minds of many investigators that X-rays, or something evolved in the production of X-rays, might have some ill effect on living tissues . . ." Becquerel accidentally burned the skin beneath his vest pocket in which he was carrying a vial of radium. The Curies, too, were burned by radium, Marie accidentally and Pierre deliberately as an experiment. And, as is well known, the deaths of Madame Curie and her daughter, Irène Joliot-Curie, have been attributed to effects of radiation. Madame Joliot-Curie was exposed in a laboratory accident, when she heroically attempted to confine the contents of a broken vial of an intensly active element while she warned her co-workers to flee.

Early concern with radiation injury has been augmented by continuing developments in fundamental and applied radiobiology. Recent reports of the National Research Council (*3*) concerning biological effects of radiations, which are closely paralleled by a report of the British Medical Research Council (*4*), have sharply emphasized the need of preventive action. The National Research Council reports describe the potentially harmful effects of ionizing radiation on this generation and on its posterity, thereby touching upon both the somatic and the genetic effects. They stress the cumulative aspects of chronic exposure, especially genetic. Ionizing radiations have been demon-

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strated to be carcinogenic and to affect the genes. Genetic effects can be created with relatively light doses. The significance of such effects, however, is far from being completely evaluated.

Epidemiological studies are contributing to our knowledge of radiation effects. For example, physicians experience an incidence of leukemia 1.75 times as great as males in the general population (*5*). March has shown that the incidence of leukemia among nonradiologist physicians is 0.44 percent, while the incidence among radiologists is 4.47 percent (*6*). More recently, preliminary analysis of data from a survey of 547 children dying of leukemia and other malignant diseases in England during the period 1953–55 definitely indicates these conditions are most frequent among those whose mothers had X-ray examinations of the abdomen during pregnancy (*7, 8*).

Potential Effects of Radiation

The following explanation of what may happen when body tissue is irradiated, though greatly simplified and undoubtedly controversial from a technical viewpoint, is useful in discussing radiation injury.

Ionizing radiation produces within a body cell one or more pairs of electrically charged fragments called ions. The number of cells affected depends on the time and intensity of exposure, the volume of tissue exposed, and the character of the radiation. Radiation from external sources is relatively less consequential than radiation from sources lodged in the tissues.

Following the production of ions in a cell, an ion pair may simply recombine or other ion combinations may form. The former event is of little concern, but the latter may cause either alteration or destruction of the cell. Destruction of the cell may contribute to the phenomenon of aging, and the only result will be a shortening of the life span. Alteration of the cell may produce either a benign or a malignant mutation. A benign mutation is not of great concern in a somatic cell, but it could be important in a genetic cell. A malignant mutation may in time form cancerous tissue. Of the potential effects of radiation on body cells then, mutation is most important.

When tissues are exposed to any amount of ionizing radiation, some or all of these effects are possible. Even minimal exposure or background exposure from natural sources contributes to the probability of an untoward effect. Therefore, the theoretical goal in prevention of radiation injury should be limitation of exposure to the absolute minimum.

The National Research Council reports attribute an average accumulated dose of about 4.3 roentgens of external radiation over a 30-year period to background radiation not under man's control; 3 roentgens to the gonads from X-rays; and a projected 30-year external exposure from fallout from testing of weapons, if continued at present levels, of about 0.1 roentgen. (The probable internal exposure is not included in these calculations.) To these exposures must be added potential occupational exposures and exposures from diagnostic or therapeutic uses of radionuclides.

Medical exposure can be controlled by laboratory techniques and equipment put to judicious use. Occupational exposures can most certainly be approached from the viewpoint of preventive medicine.

The Armed Forces have two broad areas of interest in ionizing radiation protection. These are (*a*) the problems associated with nuclear weapons and reactors and (*b*) those not directly so associated. In the Army, the Surgeon General has a special assistant for nuclear energy, who deals primarily with tant. Matters pertaining to microwave haz-emitters in medical radiology are within the purview of the chief radiological consultant. Matters pertaining to microwave hazards, nonmedical and nonweapons uses of emitters, and radiological hygiene surveys of Army installations are charged to the chief of the Preventive Medicine Division and are delegated to the Occupational Health Branch. In the newly developing field of nuclear reactors, all these people have important interests.

Scope of the Army's Problem

All of the Army's 1,025,000 military and about 435,000 civilian employees have radiographs taken as part of their preenlistment or preemployment physical examinations. Many receive additional exposure to X-rays in emergency or periodic examinations. The Army also operates induction stations for the three services. These activities employ hundreds of X-ray installations throughout the free world. These installations, utilizing a variety of machines acquired at various times and initially installed by various agencies and companies, are periodically serviced, calibrated, moved, and checked for radiological hazards. Although some of the work is done by operating personnel, the "disinterested" survey method also is used. This type of survey is conducted by personnel from the Army Environmental Health Laboratory, with the aid of outstanding consultants as necessary.

Six large Army hospitals use radionuclides for medical research and treatment, and a large number of laboratories, arsenals, and industrial-type installations use radioelements in nonmedical research and development, production, and training. Some sources used by the Army are in the order of tens and hundreds of curies in strength. All these must be monitored and surveyed periodically.

All Army users of radionuclides receive them through the standard byproduct procedures established by the Atomic Energy Commission (*9*), with the important exception that all requests must be transmitted through the Office of the Surgeon General. For approval by the Army Surgeon General, a request must show that proper receiving, handling, storage, and disposal facilities and adequately trained and experienced personnel are available. These trained persons assume responsibility for the radionuclides and supervise their use. The Army has excellent rapport with AEC and, in a sense, acts as its agent, although visiting AEC teams are always welcome to conduct checks on the Army's operations, either independently or in conjunction with our personnel.

Disposal of radioactive wastes, a responsibility of the Army Chemical Corps (*10*) with technical advice and supervision from the Surgeon General, is a major problem. Morton and Struxness of the Atomic Energy Commission have pointed out that it may well prove to be one of the limiting factors in achieving optimum benefits from nuclear energy (*11*). Relatively minute quantities of short half-lived radionuclides may be admitted to the sewage system where this practice is allowed and under strict controls. Larger amounts may be stored in appropriate receptacles pending loss of activity. Among other methods tried or studied are burial at sea below the thermocline, at a depth of a thousand fathoms, after casting into concrete or incorporation into an insoluble ceramic mass; ground disposition in certain soils having available ion exchange patterns; and disposition in such natural containment formations as the salt formations in Michigan and Kansas, the regional aquifers in the midwest and the southwest, and the closed valleys in the west.

The Army also has betatrons, industrial X-ray machines, and high-activity radionuclides for industrial radiography or for processing military items. Some radionuclides are being used with considerable success for sterilization of packaged foodstuffs. The Army uses appreciable quantities of naturally occurring radionuclides, such as radium, over which the Atomic Energy Commission now extends no control. The Army has established administrative controls for these materials similar to those for other radioactive substances (*12*).

In cooperation with the other armed services and the Atomic Energy Commission, the Army is now moving into the nuclear reactor field. Our first reactor, water moderated and designed to develop electric power and heat, has recently been completed at Fort Belvoir, Va., near Washington, D. C. This reactor, because it is near a population center, is in a building designed, according to AEC standards, to contain fully any contamination from radionuclides. The design conforms also with recommendations of the National Research Council (*3a*).

An ultimate goal for the Army in this field is an easily transported or even mobile reactor to provide heat and power in remote areas of the world where logistics of conventional fuel supply are burdensome and costly. Currently, the Army is on the threshold of this goal with a stationary prototype and can be expected to move rapidly into various applications with the accumulation of knowledge and experience. The Army Medical Service expects medical problems from power reactors to grow and is preparing for that eventuality.

Protection of Army Personnel

Army regulations require individual dosimetry, or inventory, for all personnel in an environment heavily exposed to ionizing radiation (*13*). Accurate cumulative records must be kept in a manner prescribed by tri-service regulation (*14*). In continental United States, Army installations receive film badge service from the Lexington Signal Depot (*15*), which provides the badges and the film on an appropriate periodic schedule. Exposures above 300 milliroentgens per week are reported to the installation and to the Surgeon General by telegram or telephone. If gross or multiple overexposures are indicated, technicians are sent to the installation to help pinpoint and correct the difficulty.

Many believe that the Army control measures are more severe than those of civilian counterparts. If so, it is only in adherence to common sense and to existing standards and regulations. We scrupulously observe the Atomic Energy Commission's requirements. We use the data of the various National Bureau of Standards handbooks, some of which we have borrowed wholly or in part and reissued as Army bulletins and directives. When newer information dictates or suggests modifications in these data, we publish and enforce the changes. We also issue publications specially developed for the Army.

The Army attempts to learn and comply with State and community requirements. In that respect, two pleas are in order. First, when regulations for a State or a locality are issued, we ask health officials please to send copies to the surgeons general of the three services. Second, we ask everyone to remember that the control of ionizing radiations is important to national health. As in motor vehicle or air control, maximum standardization of codes, symbols, marking, regulations, and restrictions is desirable. The practices of New York State, where National Bureau of Standards handbooks and related or similar documents and procedures are used extensively, are exemplary in this respect.

Summary

The Army's main concern with respect to prevention of radiation injury is the protection of the individual against unnecessary exposure to ionizing radiation. We consider all ionizing radiations to be potentially harmful. Our approach is essentially preventive. We try to foresee the hazards, design protective facilities and procedures, keep accurate records of users and uses, provide maximum protective and monitoring devices at each installation, and then check by disinterested survey to assure local competence and adherence to prescribed procedures and to detect hazards otherwise overlooked. National and local monitoring and investigation of noteworthy exposure support this effort.

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technical publications

Health and Demography

PHS Publication No. 502. 1956. By Halbert L. Dunn, M.D. 94 pages; illustrated. 50 cents.

Population trends and developments pertinent to present and future public health programs have been collated in this graphic presentation.

The condensed data are presented in five sections: the dynamics of population trends in the United States; population trends for major geographic areas and States; population characteristics; age and marital status; economic status and indicators of health and disease. A foreword and a postscript present the views of the author.

Directory of State Standard-Setting Authorities for Hospitals and Medical Facilities

PHS Publication (unnumbered). 10 pages. 1956.

This publication entitled "Directory of State Agencies Having Primary Legal Responsibility for Standards of Maintenance and Operation of Hospitals, Nursing Homes, Homes for the Aged, and Other Similar Facilities Except Those Operated by Federal and State Governments" briefly shows in tabular form the responsibilities of various State agencies administering or licensing seven types of medical facilities. An accompanying index lists names and addresses of these agencies.

Intended as an aid to State, local, and other health agencies in planning and administering their programs, this pamphlet was published by the Division of Hospital and Medical Facilities (administering body of the Hill-Burton Hospital and Medical Facilities Survey and Construction Program).

Industrial Waste Guide to the Commercial Laundering Industry

PHS Publication No. 509. 1956. 8 pages; illustrated. 15 cents.

Intended primarily to aid workers in the water pollution control program, this handbook was prepared by the Stream Pollution Abatement Committee of the American Association of Textile Chemists and Colorists in cooperation with the American Institute of Laundering. It was submitted for publication to the Public Health Service through the National Technical Task Committee on Industrial Wastes.

Laundry supervisors will find this publication a concise practical guide for operation of washrooms with a minimum of waste material. A section on waste treatment suggests possible solutions to stream pollution which cannot be corrected by waste reduction procedures. Some performance data are included on various waste treatment processes. The value of waste reduction methods in lowering total waste treatment costs also is emphasized.

The Circulatory System

Illustrated Guide for Nursing Education

PHS Publication No. 482. 1956. 64 pages; illustrated. 45 cents.

Designed for nursing education in cardiovascular disease, this booklet contains 20 colored diagrammatic figures with explanatory text.

This guide is also intended as a timesaver for nursing school instructors, for individual nurses, and for staff education in hospitals, industry, and public health agencies.

The schematic drawings used are reproductions from the set of colored slides on the circulatory system, produced in 1954 by the Public Health Service, and used widely in nursing education.

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