EVALUATION OF RADIATION HAZARDS IN THE PHILIPPINE GENERAL HOSPITAL

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In most of our hospitals today, very little attention has been given to radiation hazards resulting from scattered x-rays and gamma-rays from medical isotopes. We have no knowledge of how much dosage our x-ray personnel have been exposed to in the past. The consciousness of radiation protection led us to survey the radiation level in and about the Radioisotope Laboratory and the Radiology Department of the Philippine General Hospital.

The Radiology Department of the Philippine General Hospital has three exposure rooms. In Room I, there are three x-ray machines for therapeutic purposes, each with its own cave and operated at 100 kvp, 5 ma.; 200 kvp, 5 ma.; and 250 kvp, 10 ma., respectively. The nurse's table is separated from the exposure caves by a wooden wall. In Room II, there is a machine usually operated at 100 kvp, 200 ma., for diagnostic purposes. Built in this room is a cave where about 250 mg. of radium is kept. In Room III, there is an x-ray machine usually operated at 80 kvp, 50 ma., also for diagnostic purposes.

The cave in the Radioisotope Laboratory keeps a maximum of about 30 mc. of radioactive iodine shielded with lead blocks.

In a situation like ours where radiation monitoring is not so well equipped yet, measurement of radiation becomes a problem. The radioisotope laboratory of the Philippine General Hospital has a scintillation counter for iodine suitable for our purposes. The method was to count the incident x-ray or gamma photons per second, and from this number and from the energy of the radiation, deduce the corresponding dosage rate in r-units.

APPARATUS

The scintillation counter utilizes a NaI (TI) crystal, ¾ inch in diameter and ¾ inch long, incorporating a DuMont phototube no. 6292. The counter was hooked into a linear count rate meter. The time constant of the circuit was chosen so as to yield an overall maximum percentage error in the meter reading of about 1%. After testing the phototube characteristics, the operating voltage was set at 900 volts. There was a background of about 150 counts per minute. Assuming that this background is due to cosmic radiation, this number would correspond roughly to 0.1 mr/hr. Evidently, the background reading is not due to electronic noise.

Calibration of the instrument was done by computing for the effective area of the crystal for different photon energies, using Klein-Nishina's formula (1) for the absorption coefficient in the Compton range. Based on our experience, the theoretical effective area was multiplied by a factor of 1.25 to allow for scattered radiation in the shield. The effective area of the crystal for iodine gamma rays which was determined experimentally by the manufacturer was then checked against the calibration formula.

METHOD

Radiation level at various spots in and about the three exposure rooms in the radiology department and the radioisotope laboratory was counted. The incident intensity is given by

$$I = \frac{NE}{A}$$

where I is the incident intensity in ergs/cm².⁄sec., N the count rate registered by the counter in counts/sec., A the effective area of the crystal in cms²., and E the energy in ergs of the incident radiation. In the absence of information on the voltage waveform of the power supply of the x-ray machines, the energy of the x-radiation was based on the peak voltage. It is to be noted that this voltage does not always indicate the photon energy of the scattered beam which is usually of lower photon energy than the direct beam.

The dosage rate was computed from I on the basis of the definition of the roentgen equivalent physical (rep), namely: 1 rep is that amount of x- or gamma-radiation which causes an absorbed energy of 93 ergs per gram of tissue. Tissue is assumed to have more or less the absorption characteristics of water.

RESULTS

Table 1 shows the calculated dosage rate a person would be exposed to at the corresponding places indicated. When the measurements were taken, 25 mc. iodine was kept in the radiation cave of the Radioisotope Laboratory. The dose rate of about 10 mr/hr is simply an estimate since this level was found to be beyond the range of the counter used. A good estimate is obtained by considering the scattered radiation to be one-thousandth in intensity compared to the primary beam. On this basis, the values in Table 1 check with the measurements (2) of the usual direct x-ray dosages involved in medical applications.

Table 2 shows the maximum permissible level of dosage per week for personnel. These values are determined to safeguard radiation personnel against immediate physiological effects. For the public, the limits shown should be divided by 10 to minimize severe genetic effects. These values are based on the latest recommendations of the U. S. National Committee on Radiation Protection and Measurements. In evaluating occupational hazards, conservatism is always a safe guide.

The "hottest" dose rate of 10 mr/hr in Table 1 lasts only for less than a second for every x-ray shot. There are about 70 cases handled in room III every day, giving the personnel an accumulated dose of about 12 mrep per day or 66 mrep per 40-hour week.

The therapeutic exposures in room I last in longer intervals. Based on a continuous 40-hour week, the nurse would receive a dose of 80 mrep per week. This number is to be compared with the 90 mrem limit in Table 2.

At the side corridor by room II, the disinterested public can acquire a dose of 13 mrep per 8-hour day. The conservative limit of 9 mrem per week for critical organs of the public renders the corridor an unhealthful waiting place for the patients. However, this dosage of 13 mrep is negligible compared to the dosage of about 1 to 10 rep that a patient receives in the common x-ray examinations.

There are no hazards in the Radioisotope Laboratory.

COMMENTS

Calculation or radiation survey does not give us a record of dosage a particular individual has been exposed to. A more faithful reproduction of individual exposure is rendered by a film monitoring system. One way to encourage a film badge monitoring service is to have one central film badge service for the different interested x-ray and radioisotope laboratory units in our country. It is hoped that with our consciousness of radiation hazards, greater care will be taken in utilizing radiation for medical purposes and that a record of accumulated dosage be kept for each individual.

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TABLE 1

RADIATION LEVEL IN AND ABOUT THE RADIO-ISOTOPE LABORATORY AND X-RAY DEPARTMENT OF THE PHILIPPINE GENERAL HOSPITAL.

Place	Dose Rate in mrep/hour.
Radioisotope Laboratory, 25 mc. iodine.	
Closest approach of person to shield of isotopes inside cave.	0.5
Outside cave by the glass window.	0.3
Outside cave by the concrete and lead-lined walls.	background
X-ray Room I, 200 kvp, 5 ma.	
By the nurse's table when the machines are on.	2
X-ray Room II, 100 kvp, 200 ma.	
Inside x-ray room when machines are off (radium background)	0.5
At 2 meters from the door of radium cave when machines are off.	2
Behind personnel shield when the machine is on.	0.6
X-ray Room III, 80 kvp, 50 ma.	
Machines off.	background
At 3 meters from the machine when it is on.	10?

TABLE 1 (Continued)

Place	Dose Rate in mrep./hour.
Side Corridor by X-ray Room II (Public Place)	
By the waiting bench just outside the glass window of the radium cave.	1.7
By the same waiting bench just outside the concrete wall of the radium cave.	0.5

TABLE 2

MAXIMUM PERMISSIBLE LEVELS FOR PERSONNEL.

	Level per week in mrem.
Critical organs.	90
Whole body skin.	190
Hands and forearms (fractional exposure).	1400