

MEDICAL PHYSICS II

Radiation Therapy

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The close relation of physics and medicine is illustrated in the development of x-ray and radium therapy. Twenty-five years ago roentgen rays were produced by temperamental gas tubes connected to transformers with mechanical rectification. The maximum potential was about 130,000 volts. Roentgen ray output was erratic and not easily reproduced; only with great difficulty could the amount and the kind of radiation be estimated. Transfer of a given dosage from one machine to another was a problem since the outputs of two machines might vary widely, even though such technical factors as voltage, amperage, distance, and filter were identical. The common methods of calculating dosage from these factors alone were therefore often condemned to failure.

Physicists and radiologists working together steadily improved x-ray apparatus and methods of treatment.^{1,2,3,4} Modern generators produce potentials up to several million volts, and hot filament x-ray tubes operate on these high potentials. Radiation output is constant and reproducible. Today both quantity and quality of radiation can be readily and accurately determined.

Roentgen ray quantities are expressed in an internationally accepted dosage unit, the roentgen; the unit of quality is the half value layer, which classifies x-rays according to their penetrating power. Absorption and scattering of x-rays within the body have been studied for many radiation qualities and for numerous therapeutic technics. The results of these studies have been arranged in convenient tables from which surface doses, depth doses, and exit doses for the patient are quickly ascertained. Numerous clinical and biological dosages have been determined in roentgens. Thus the basic factors in production and application of roentgen rays are now well understood and controlled by the radiologist.

The essential features of radium therapy have likewise been explored and data classified within the past twenty-five years. Radium and its decay products emit alpha, beta, and gamma rays, all of which are used in radium therapy.

Alpha rays are a stream of positively charged helium nuclei; they have a large mass and are easily stopped by a few centimeters of air

or by less than 1 mm. of skin. In one form of alpha ray therapy an ointment containing radon is applied to the skin.⁵

Beta rays are electrons. They have various energies and can penetrate 1 cm. of tissue; they are completely stopped by 0.5 mm. of platinum filter or its equivalent. Beta ray therapy, which is also superficial, employs radium plaques or thin-walled glass tubes filled with radon.⁶

Gamma rays, like x-rays, are photons and have much greater energy than the easily absorbed alpha and beta rays. To produce x-rays of the same quality as the most penetrating gamma rays of radium would require about 3 million volts. If sufficient radium were available to duplicate common deep x-ray therapy technics which require about 200,000 volts, much greater depth doses would be obtained with the radium. However, about 360 Gm. of radium, one-third the total produced since its discovery, would be needed to produce an intensity of about 20 roentgens per minute at a distance of 50 cm., which is customary with x-rays. To compensate for small amounts ordinarily available, the radium must be brought closer to the skin, with a consequent loss of the relative depth dose. The loss is not caused by any change in penetrating power of the rays but is purely geometric and is governed by the inverse square law. In external gamma ray therapy, so-called teletherapy, the radium or radon in applicators of various sizes and shapes is placed at certain distances from the skin.

Corresponding to the surface application of radium is the Chaoul and Philips x-ray technic^{2,3,4} in which the windows of the x-ray tubes are brought into close contact with the skin. These tubes are operated at about 60 kilovolts and consequently do not give out rays as penetrating as gamma rays; however, with this technic only superficial action of the rays is intended.

Two other gamma ray technics are used: Intracavitary radium therapy employs radium or radon tubes singly or in combinations of two or more. In interstitial radium therapy various types and forms of radium or radon implants are left in place permanently or removed after a time.

Dosage for these three types of gamma ray therapy depends upon the amount of radium or radon used, the kind of filtration, and the shape and geometric arrangement of the applicators. Determinations and interrelations of dosages for a great variety of technical conditions have been charted and tabulated by physicists and radiologists. The most generally used tables are those of Paterson and Parker.² These tables have been simplified by adoption of the gamma roentgen, a

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dosage unit for gamma rays of radium analogous to that for roentgen rays. An older unit for gamma ray therapy, the milligram element hour, is related to the gamma roentgen, since 1 mg. of radium element filtered by 0.5 mm. of platinum at 1 cm. distance emits 8.5 gamma roentgens per hour. Clinical and biological dosages expressed in gamma roentgens have been gathered empirically for a large number of treatment conditions.

SUMMARY

Through close collaboration of the physicist and radiologist dosages have been standardized for the various forms of x-rays and radium therapy.

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