February 22, 1967

CINCINNATI GENERAL HOSPITAL IRRADIATOR

Primary interest of the University of Cincinnati group is to study the metabolic effects of ionizing radiation in humans and midline doses of the order of 25 to 200 rad are used. We use a single Cobalt 60 source housed in an Eldorado A (Atomic Energy of Canada) unit. In our set-up distance requirements have been minimized by placing the patient in a sitting position with lower extremities raised and with the head tilted slightly forward. The patient is thus fitted in a square area of about 30 inches on each side (actually within the 50% isodose line). The cobalt 60 field for total body radiation using the present source is shown in slide 1. From the fall off of dose rate with inverse square and the deviation found in this inverse square law extrapolation as the wall of the room is approached, the distance of 282 cm to patient midline was chosen. Here it is seen that the field size is approximately 73 by 74 cm to the 50% isodose line. The approximate locations of the center of the head, trunk, and knee areas are noted in the slide. The irradiation is delivered by giving half the specified exposure laterally through one side of the patient. The platform on which the patient is seated is then turned around and the other half exposure delivered laterally through the other side.

Preliminary measurements made in a masonite phantom using dosimeters placed on lateral surfaces and at the midline of the head, trunk, and knee portions of the phantom are shown in slide 2. With the Cobalt source located at 282 cm. to the patient midline, which is also approximately 56 cm. from the room wall, exposure rates were measured at points A, B, and C, at the head level and D, E, and F at trunk level, and G, I, and K at knee level. If the dose rates at B, E, and I are compared, it is seen that the maximum variation in these exposures is about 16%. Even though there is fall off of the exposure at the head and knee regions, the less attenuation of the beam by the less thickness of tissue at these positions tends to further equalize the exposure.

The exposure to the patient is determined as follows:

The percentage depth dose at a tissue depth of half the lateral dimensions of the patient for a 400 sq. cm. field area and a source-skin distance of 80 cm. is given. Depth dose at the greater source-skin distance used for the patient was found by multiplying this depth dose by the so-called F factor postulated by Mayneord and Lamerton. By using the corrected depth dose at the patient midline (1/2 lateral dimension of the trunk) and the conversion ratio of .97 rads per roentgens for the Cobalt 60 gamma radiation, surface exposure was then calculated. Dividing by the backscatter factor gives the air exposure at the position of the surface. Air exposure at midline required to give the desired midline dose in rads. This is in essence for the distances involved here the same as using the tumor-to-air ratio; that is, using the tissue exposure to air exposure at location of tissue as the ratio for obtaining the air exposure at midline.

It is realized that the assumption made here is one of uniform tissue attenuation. Also the possibility of some deviation from the true value by the use of the F factor extrapolation. However, a direct comparison of the calculated and measured phantom doses were made for a patient having the same lateral trunk dimension as the masonite phantom. The relative depth dose for each lateral exposure to this patient is given in slide 3. Indicated by the crosses are measurements made in the masonite phantom and which compare quite well with the calculated doses. The combined dose of the two radiation fields is also given in this figure and shows a good homogeneous distribution through this patient (+ 8% variation). In slide 4 the maximum variation in lateral dose distribution is shown for the extreme lateral dimensions for the patients in the total body study, Minimal lateral dimensions is 24 cm. and a maximal lateral dimension of 36 cm. For the 24 cm. lateral dimension, a maximum variation in dose is $\pm$ 3%, whereas it attains a value of + 11% for the patient having the 36 cm. lateral dimension. This check has also been made recently with the Alderson Rando Phantom and Lithium Fluoride with the same good agreement.

As an additional experimental check of the radiation exposure conditions, ion chamber dosimeters were placed in our early experiments (now we use lithium floride dosimeters) on lateral sides of the trunk, head, and knees of patients during exposures. These readings do, in general, agree quite well with the calculated values for these positions.

We have also performed some partial (half) body irradiations. Slide 5 indicates results of measurements made with lithium fluoride to determine the exact field size. For the 50% isodose line, a field size of 37½ cm. by 73½ cm is given. The xiphoid was chosen as the point on the trunk that determines the uppor or lower edge of the beam. This choice of the xiphoid results in 58% of the body being irradiated for partial (lower) body as compared to 42% of the body for partial (upper) body irradiation. Measurements were also made in the Alderson Rando phantom using lithium fluoride to determine the fall off of the beam beyond the 50% isodose line. Slide 6 shows relative doses for Cobalt 60 partial body (upper) irradiation as measured with Tl 100 powder at the center of the Alderson Rando phantom using lateral radiation. The dose drops off appreciably here and it reaches a level of a few percent at 4 to 5 inches below the edge of the beam. For the lower half irradiation, (slide 7), the exposures at the head level are in the order of one to 1½%.

The approach given above attempts to compensate to some extent for the different lateral dimensions of the patient by giving the same midline absorbed dose in rads. However, the integral doses for these patients may still be different. In the School of Aviation Medicine report written by W.K. Sinclair and by Art Cole on the technique of dosimetry for whole body x-irradiation of patients. Mayneord's concept of average dose was used in an attempt to further correlate doses between patients by compensating for the patient's size. In this concept the trunk dimensions are compounded with the body values for the limbs in order to obtain the final average dose (average dose for the limbs found by taking 21/40 of the lateral dimension) for the whole body based on the lateral trunk dimension. From the body weight and the average dose, the integral dose expressed in megagram·rads is determined. We have done this by computing new curves for the

Cobalt 60 radiation. These are curves which show relationships between skin dose and patient lateral dimension and between average dose divided by skin dose and the patient lateral dimension for the trunk only and also for the limbs only. With this technique we have computed integral dose to the patient. Table in slide 8 presents midline dose (rads) with associated integral dose calculations for fairly extreme patient sizes (weights and lateral dimensions) in the various dose groups.

We have found it somewhat convenient (rightly or wrongly) to talk in terms of integral dose in attempting to compare some of the post-irradiation syndromes. Slide 9 gives the frequency of prodromal symptoms following whole body irradiation in human cancer patients. The regression curve for this data provides some information as the stimulus (prodromal symptoms) at which a proportion P of an irradiated population would be expected to respond.

Of particular application for integral dose was to attempt to correlate post-irradiation symptoms for whole body and partial (half) body irradiation (slides 10 and 11).

In the presentation, I have included the terms air exposure, tissue exposure, tissue absorbed dose, average dose, and finally integral dose. The predicament is that all of these terms have been for dosimetry expression in total body irradiation studies. Although all of us realize that an expression for dose standardization is needed, we are unsure as to how this can be approached. The immediate need is a standardization of the air exposure between the various centers. If this is done and detailed patient description is made, we may be better prepared to make the transition to some standard terminology in the future.

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