A rough estimate of the gonadal dose was made for the 29 well specified cases. Using the method of Ellis (as described in Go68) and knowing the entrance exposure, the age and sex of the patient, and the ration of scattered to primary X-rays in tissue as a function of KVP and distance, one may estimate the mean gonadal dose as 18 mrads with a range of 3–51 mrads.

Current Work
From 8 November 1974 to 17 March 1975 all patients (total 10) had a LiF TLD ribbon placed on the skin in midfield and the mean dose was found to be 990 mrads with a range from 140 to 4200 mrads. On 18 March 1975, a new X-ray unit was introduced that operates at 80 KVP and 1 mA. This unit is restricted to fun in 12 sec bursts with a typical total run time of 36 sec. A preliminary study shows the patient exposures to be approx 500 mR.

Discussion
In a series of 91 patients, Gough et al. (Go68) found that cardiac catherization and angiocardiography gave a mean skin dose of 47 rads with a mean gonadal dose of 25 mrads in males and 39 mrads in females. Since the bulk of the patients in our study are infants and preschool children, a higher ratio of gonadal dose to entrance dose is seen compared to Gough et al. With the new X-ray unit in operation, exposures for the roentgen densitometer should be about two decades below that of conventional angiocardiography.

K. DAVID STEIDLEY
Radiotherapy Department
St. Barnabas Medical Center
Livingston, NJ 07039

References


Shielding for Multiple Sources of Radiation
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At the Arkansas Department of Health, the Division of Radiological Health frequently reviews the adequacy of proposed shielding for new X-ray facilities. It became apparent that when shielding calculations were done for suites with radiographic and fluoroscopic capabilities and with spot film devices, three essentially independent sources of radiation must be considered as contributing to the exposure at a particular point. Consulting the National Council on Radiation Protection (NCRP) Report 34 (NCRP70) revealed only the general guidance that if two sources could contribute to the exposure in a room, 1 half-value layer should be added to the calculated requirement for either source. It was believed that a more exact solution was needed to recommend the total shielding required and the following approach was taken:

Suppose shielding calculations indicate that for source 1, \( N_1 \) half-value layers (HVLs) are needed to reduce the unshielded exposure \( X_1 \) to some limit \( P \). (For example, suppose 1 HVL is needed to reduce an exposure to 10 mR/week.) This may be expressed as

\[
\frac{X_1}{2^{N_1}} = P. \tag{1}
\]

Suppose that source 2 required \( N_2 \) HVLs to reduce the unshielded exposure \( X_2 \) to \( P \), and so forth through the nth source with \( N_n \) HVLs and \( X_n \) exposure. It may be seen that the total exposure from all the sources is \( X_1 + X_2 + \ldots + X_n \). We would need some \( N \) HVLs to reduce the exposure to \( P \):

\[
\frac{X_1 + X_2 + \ldots + X_n}{2^N} = P. \tag{2}
\]

But since \( X_i = 2^N P \), we may write (2) as

\[
2^N = \frac{2^n P + 2^n P + \ldots + 2^n P}{P} = 2^n + 2^n + \ldots + 2^n. \tag{3}
\]

Taking the logarithm of both sides of equation (3), we have

\[
\ln 2^N = N \ln 2 = \ln (2^n + 2^n + \ldots + 2^n)\]

or

\[
N = \frac{\ln (2^n + 2^n + \ldots + 2^n)}{\ln 2}. \tag{4}
\]
where $N$ is the correct amount of shielding required to account for all the sources.

For only two sources of radiation, as is often the case, equation (4) reduces to

$$N = \frac{\ln (2N^+ + 2N^-)}{\ln 2}.$$  \hfill (5)

It is accepted practice to use the maximum machine rated kVp in considering shielding for an X-ray facility (Ce69). The use of equation (4) requires that the maximum kVp of each source of radiation (radiographic "overhead" tube and fluoroscopic tube) be the same. Since it has been noted by this investigator that the maximum kVp for the radiographic machine is generally slightly greater than that of the fluoroscopic machine, the conservative solution is to use the higher maximum rated kVp in the calculations.

E. Lynn McGuire

Division of Radiological Health
Arkansas Department of Health
4815 West Markham
Little Rock, AR 72201

References


Use Factors for Medical Linear Accelerators

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Shielding barriers represent a significant fraction of the construction cost in radiotherapy departments using high energy photon machines. The availability of space is frequently limited. For both these reasons it is highly desirable to use the minimum amount of shielding that is consistent with the requirement that radiation exposure in the surrounding areas be reduced to safe and acceptable levels. The International Commission of Radiological Protection (ICRP75) and the United States Nuclear Regulatory Commission (USNRC75) have directed the attention to the principle that dose levels should be "as low as is reasonably achievable." Braestrup and Wyckoff (Br73) have estimated the economical consequences of shielding to levels of 100, 10 or 1 mR/week. Their analysis indicates that 10 mR/week is a "reasonably achievable" design goal and that cost rapidly increases when the dose level is reduced further. Consequently, when shielding to the level of 10 mR/week, the cost-to-benefit ratio of oversafe calculations becomes high, and to counteract this, it is essential that accurate physical and other parameters are available for use in the shielding design.

In a recent installation in our department, we evaluated the projected use of a 4-MV linear accelerator in detail. Some results of this study are presented in this report.

Records of treatments of patients during 1 week in January 1974 on three 4-MV linear accelerators were analyzed to determine the number of patients, treatments and fields; the gantry angles used to deliver the radiation; the field sizes; and the exposures used. The exposure is that which would occur at the isocenter, 80 cm from the source, without the patient. These installations treat patients for 8 hr four days a week and for 5 hr one day a week. Each patient has each field treated four or five times each week.

A summary of the data is given in Table 1. The average workload for these units was about $6.5 \times 10^6$ R/week at 80 cm distance from the source. The workload is specified by NCRP (NCRP70a) as the weekly exposure of the primary beam at a specific distance from the source. The workload is usually given in R/week at 1 m for accelerators and teletherapy units. NCRP (NCRP70b) considers a typical workload 100,000 R/week, which is significantly higher than our figure. However, the two workload values are consistent with each other, since NCRP assumes that 50 patients are treated 5 days a week, i.e. the average exposure per treatment is 400 R, corresponding to our average figure of 433 R. The difference in total workload consequently is a result of the differences in the number of treatments delivered each day. The fact that we specify workload at 80 cm while NCRP uses 100 cm does not influence the comparison, provided the two distances apply to the distance between source and isocenter and patients are set up for treatment in the same relation to isocenter in both cases.

It should be noted in Table 1 that our average field size, 253 cm$^2$, is appreciably smaller than the 400 cm$^2$ quoted by NCRP (NCRP70c). Our field size values are for the collimator opening at 80 cm and do not include the effect of shielding blocks.

The use factor or beam direction factor is defined