MEASUREMENT OF DOSE OUT SIDE THE IRRADIATED VOLUME BY USING LOCALLY FABRICATED WATER PHANTOM

M. Rafi Uddin[a], M. Jahangir Alam[b] and G. U. Ahmad[a]
[a]Department of Physics, BUET, Dhaka, Bangladesh.
[b]Delta Medical Center Ltd., Dhaka, Bangladesh

Abstract: Measurements are performed for a cobalt beam to determine the extent of leakage and contribution of scattered radiation to have an idea for estimation of dose to points in the body outside the primary beam. It may be several centimeters outside the treatment field and may be as much as 36% of the central axis dose. Doses outside the field were calculated upto distances where until 5% of the central axis dose was obtained. The scattered and leakage radiation show a strong dependence on field size and distance to the beam axis and is predominant only at short distances.

1. INTRODUCTION

It has been well documented in the literature that there exists a significant amount of low-energy radiation that contributes to the photon beam used in radiotherapy [1]. There are a number of important dosimetric properties of a therapeutic photon beam resulting from this undesirable radiation. This unwanted radiation comes from scattering generated by the patient and machine components, and leakage through the machine shielding and collimator [1-4] and the floor, walls or ceiling [5]. The contribution of the scattering from floor, walls or ceiling is negligible [5]. The spatial extent of this unwanted radiation is not limited to the radiation field defined by the collimators. A significant amount of this radiation is delivered to region outside this field. Existence of the unwanted radiation outside the collimated field may have significant clinical consequences. If the amount of scattered and leakage radiation is substantial, the patient may be receiving a significant dose to regions, which have been considered to lie outside the radiation field and thus assumed to receive minimal dose. The absorbed dose outside the radiation fields is clinically important, potentially affecting cataract formation, gonadal function, and fertility [6]. This dose can also be responsible for exposure to the fetus in a pregnant woman [3,7], and dose to breast and carcinogenesis may be a concern. In order to assess the extent of this potential problem, the present set of experiments was undertaken. In the present study, this unwanted radiation has been measured as a function of the distance outside the primary beam, and field size.

2. MATERIALS & METHODS

Measurements were performed in a locally fabricated water phantom of dimensions 45cm × 45cm × 30 cm at 5.0 cm depth for horizontal beam. In the present study, a 0.1 cc ion chamber type 23323 in conjunction with a PTW UNIDOS electrometer has been used for dose measurement. Scattered and leakage doses were measured for the field sizes $10\times10cm^2$, $12.5\times12.5cm^2$, $15\times15cm^2$, $17.5\times17.5cm^2$ and $20\times20\ cm^2$ up to a point where we got 5% dose of the central axis. During this measurement, source to surface distance was kept at 80 cm.

3. RESULTS AND DISCUSSION

Fig. 1 shows the doses outside the beam as a function of the distance from the edge of the field. It was found that doses outside the beam are about 28-36% of the central axis dose at 1.0 cm from the edge of the field and 9-13% at 2.0 cm distance from the edge of the field. The dose within 3 to

5 cm distances from the edge of the field for different field sizes was found to be 5% of the central axis dose. Fig. 1 also shows that the percent of central axis dose as a function of distance from the edge of the field is almost exponential [1]. Points less than 1 cm from the beam edge were not evaluated as these fall too close to penumbra of the primary beam [8,9]. The most obvious aspect of the curves is that the doses outside the primary beam decreases with increasing distance from the field edge. The doses near the field edge are high because of penumbra [8] of the primary beam. Another aspect of these curves is the increase in dose with increase in field size. This agrees well with some previous works [1-4,7,8]. Higher doses were obtained in a few cases - these may be due to ageing of the machine. P.H van der Giessen [5] has shown that collimator-related radiation dose was about 3 times higher than that from the more modern machine. Fig. 2 shows that dose outside the treatment area is a function of field size, the doses being higher for the larger field sizes. As might be expected, the magnitude of the out-of-field radiation increases with the field size. The dependence appears to be linear with field dimension, but this dependence may be merely an empirical observation. Our results show good agreement with the results obtained by G. Starkschall et.al.[1]. Both the figures show that doses outside the primary beam increases with field size. This can be explained by the variation of the different components of the total secondary dose. Near the field, the scattered radiation from the patient is predominant. As the distance from the field edge increases, the radiation scattered by collimator, the transmission through the collimator and the machine leakage become predominant [2]. The scattered radiation from the collimator is presumably coming mainly from the face of the beam-defining jaw seen from the point of measurement. For this reason, the scatter contribution from the jaw at this point will increase with the irradiated area of that jaw.

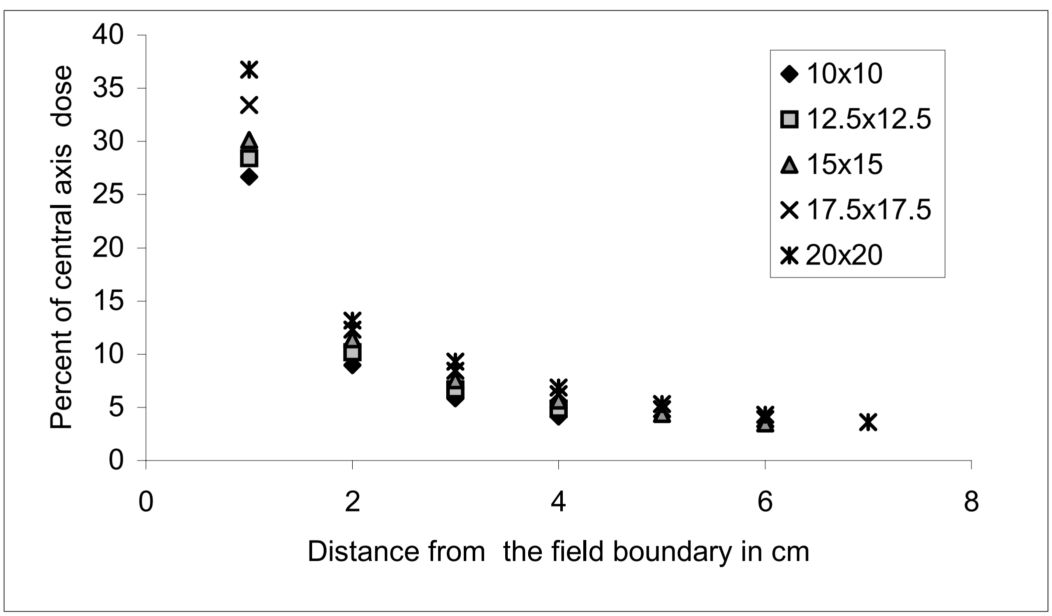

Fig. 1. Variation of doses as a function of distance from field boundary.

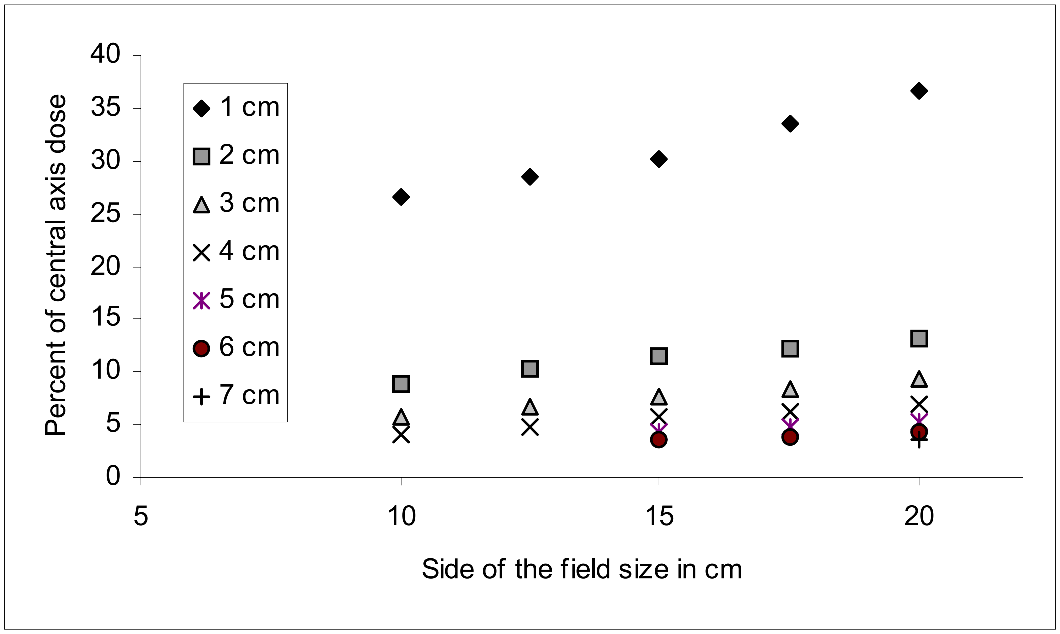

Fig. 2. Field size dependence of out-of-field radiation for different distances from the field edge.

4. CONCLUSIONS

A significant amount of radiation is available to points outside the treatment area as defined by the collimators. If young patients are treated with radiation it is essential that the dose to the gonads be kept as low as possible to keep the risks to the offspring at an acceptable level. And should pregnant patients be presented for radiation therapy and this therapy cannot be postponed, keeping the dose to the fetus as low as possible is evidently also of utmost importance. Specific precaution should be taken to shield the fetus from the from the unwanted radiation. However, when knowledge of the absorbed dose outside the treatment area is essential for the decision to treat or not to treat, the dose cannot be approximated by measurements and has to be estimated on the basis of available data, for instance measurements in phantoms.

REFERENCES

1. G. Starkschall, F.J. St. George, and D.L. Zellmer, 1983. Surface dose for megavoltage photon beams outside the treatment field, Med. Phy. 10(6), 906-910.
2. P. Francois, C. Beurtheret, and A Dutreix, 1988. Calculation of the dose delivered to organs outside the radiation beams, Med. Phy. 15(6), 879-883.
3. P.H. van der Gissen and C.W. Hurkmans, 1993. Calculation and measurement of the dose to points outside the primary beam for ^{60}Co gamma radiation, International J. Radiation Oncology Biology Physics 27, 717-724.
4. D. Greene, P.G.G. Karup, C. Sims and R.J. Taylor, 1985. Dose levels outside radiotherapy beams, Br. J. Radiol. 58, 543.

5. P.H van der Giessen, 1996. Collimator related radiation dose for different cobalt machines and linear accelerator, International J. of Radiation Oncology Biology Physics 35, 399-405.
6. T.F. Sandeman, 1966. The effects of x irradiation on male human fertility, Br. J. Radiol. 39, 901.
7. Benedick A. Fraass and Jan van de Geijn, 1983. Peripheral dose from megavolt beams, Med. Phy. 10(6), 809-817.
8. J.L. Horton, 1984. Dose in the buildup region outside the primary beam, Med. Phy. 11(3), 331-334.
9. Faiz M. Khan, The Physics of Radiation Therapy, 2nd edition, Williams & Wilkins publisher, USA.