TECHNICAL NOTE

Variations in 6MV x-ray radiotherapy build-up dose with treatment distance

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Abstract

Dose in the build up region for high energy x-rays produced by a medical linear accelerator is affected by the x-ray source to patient surface distance (SSD). The use of isocentric treatments whereby the tumour is positions 100cm from the source means that depending of the depth of the tumour and the size of the patient, the SSD can vary from distances of 80cm to 100cm. To achieve larger field sizes, the SSD can also be extended out to 120cm at times. Results have shown that open fields are not significantly affected by SSD changes with deviations in percentage dose being less than 4% of maximum dose for SSD's from 80cm to 120cm SSD. With the introduction of beam modifying devices such as Perspex blocking trays, the effects are significant with a deviation of up to 22% measured at 6MV energy with a 6mm Perspex tray for SSD's from 80cm to 120cm. These variations are largest at the skin surface and reduce with depth. The use of a multi leaf collimator for blocking removes extra skin dose caused by the Perspex block trays with decreasing SSD.

Key words radiotherapy, high energy x-rays, skin dose, SSD

Introduction

High energy medical linear accelerators are used for the treatment of cancer in radiotherapy. X-ray beams are used to deposit absorbed dose at depth within a patient at the site of the tumour. High energy x-rays produce a skin sparing effect whereby more dose is deposited at depth than in the skin tissue region[1-4]. This effect is due to longitudinal disequilibria of electrons excited by the high energy x-rays. Skin doses are highly variable depending on patient specific treatment parameters such as the field size, use of beam modifying devices and the SSD. With isocentric tumour treatment whereby the tumour is located at the isocenter, the SSD can vary significantly. This effect changes the parameters of clinical treatment and the distance of the skin from electron contamination producing devices located in and near the head of the medical linear accelerator. Excessive radiation to a patients skin can cause early radiation effects such as erythema or late effects such as hypoxia and telangiectasia[5]. The note quantitatively investigates the effects of SSD on skin dose delivered using a 6MV x-ray beam.

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Received: 13 August 2002; Accepted: 28 May 2003

Materials and methods

Measurements were performed on a Varian 2100C medical linear accelerator at 6MV peak energy. It produces an energy spectrum with a mean energy of approximately 1.5MeV. Photon beam measurements were made using an Attix Model 449 parallel plate ionization chamber in a solid water[6] stack phantom. The chamber was connected via a triaxial cable to a Keithley model 2540 electrometer at 300V bias voltage. Percentage dose build up curves were measured on the central axis for various beam configurations. The source surface distance was varied from 80cm up to 120cm which includes most clinically used SSD's. Open field and blocked field were investigated. Blocking was performed with the use of a 6mm thick, Perspex blocking tray. These devices are used commonly in conjunction with lead blocks to attenuate x-rays which would normally be incident on critical organs or areas which do not require treatment. The block tray is located 65.4cm from the x-ray source on the head of the linear accelerator. Measurements were made in 1mm intervals from 0mm to 15mm depth within the solid water phantom which represents the build up region.

Results and discussion

Figure 1 shows the build up curves for a 10cm x 10cm field (as at 100cm SSD) with various SSD's ranging from 80cm up to 120cm. As can be seen the percentage dose compared to maximum does not vary significantly with

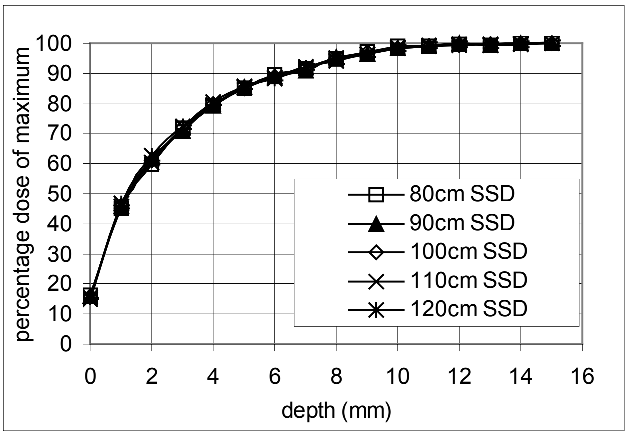

Figure 1. *Percentage dose build up curves for a 10cm x 10cm 6MV x-ray beam at various source to surface distances ranging from 80cm up to 120cm. No significant variation is seen.*

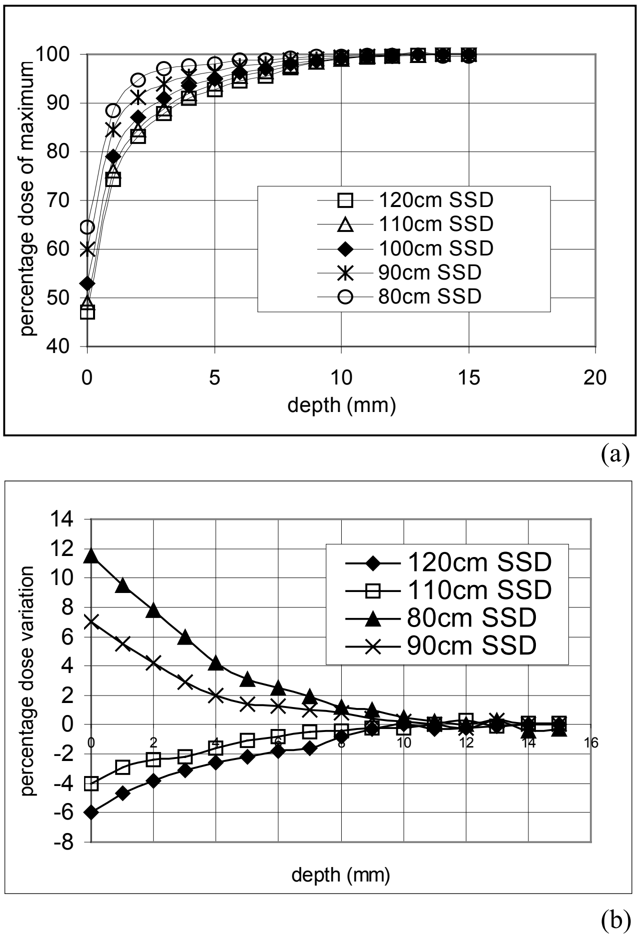

Figure 2. *a) Percentage dose build up curves for a 30cm x 30cm 6MV x-ray beam with a 6mm Perspex block tray at various source to surface distances ranging from 80cm up to 120cm. Significant differences are seen especially within the first few millimetres. b) Percentage dose differences from the 100cm SSD build up dose curve for other SSD's with the beam configurations given in figure 2a.*

SSD. The largest difference seen is near the surface which is approximately 2% when all beams are normalised to 100% at their relative Dmax values. Note the absolute doses are different due to the variation in source to surface distance which will follow an inverse square relationship due to the near point source nature of the x-ray beam produced. Similar results are seen for all field sizes up to 40c x 40cm (maximum attainable) for open fields. The fact that the field size is still quoted at the isocenter (ie the collimator positions remain unchanged) would explain the closeness of the build up doses measured. The area inside the treatment head of the accelerator which produces and allows electron contamination to escape remains constant as the SSD is varied. Electrons produced within the head of the accelerator are relatively high energy (ie a range of up to 15mm in water). Thus when these electrons are required to travel say 10cm more or 10cm less in air, it will not significantly change their range in the phantom by a sizeable amount. A similar scenario is expected for photons where a change in travelling distance in air is of the order of 10cm of centimetres, no substantial change is spectral components is expected.

Figure 2a shows the build up dose for a 30cm x 30cm field size with a 6mm Perspex blocking tray at various SSD's. A significant variation is build up dose is recorded over the range of 80cm SSD to 120cm SSD. This is highlighted in Figure 2b which shows the % deviation from the 100cm SSD percentage dose curve for the other field sizes. Surface dose differences of 17% of the maximum dose can be seen as SSD varies from 80cm to 120cm. This value increases to 22% for a 40cm x 40cm field. These results point towards the measurable difference in low energy electron contamination produced by the Perspex blocking tray being recorded at different SSD's. As these electrons have a large angular distribution it is hypothesised that their dose contribution decreases quite considerably with increasing SSD. The clinical significance of these results is that for open fields no significant change in dose delivered to the skin and subcutaneous tissue with isocentric or extended treatments. However with the use of block trays, the effects of SSD changes the dose delivered to this region. Increases in skin dose can cause early radiation effects such as erythema or late radiation induced effects such as hypoxia and telangiectasia where the skin permanently thins and become more injury prone and cosmetically unappealing. The use of a multi leaf collimator to produce field blocking removes the use of a block tray and blocks for radiotherapy. Skin dose with a Varian multi leaf collimator is found to behave similar to open field doses as each leaf acts like a small secondary collimator and does not introduce a significant amount of electron contamination into the x-ray field. Thus the use of a MLC would significantly reduce the skin dose delivered to a patient especially when the patient is treated isocentrically and thus the SSD's are reduced to below 100cm.

Conclusions

The effects of source to surface distance produces a minimal effect of dose for open field beams however a significant effect is seen for blocking trays at 6MV x-ray energy. The dose in the build up region increases with decreasing SSD for fields with blocking trays due to the influence of electron contamination produced by the Perspex blocking tray.

Acknowlegements

This work has been fully supported by a grant from the Research Grants Council of HKSAR, China (Project No. CityU 1051/02P).

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