Influence of an Air Gap between Bolus and Patient Skin on Electron Beam Dose Characteristics

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Introduction

In electron beam therapy bolus is often used to conform as closely as possible to the target volume while avoiding critical structures in the depth. In most cases a flexible bolus can cover the skin without air gap. However, under certain conditions it is difficult –or even not possible– to avoid air gaps between bolus and patient without reducing treatment quality. In a special clinical case in our hospital (USB) bolus was used in the neck region in combination with a head fixation. The fixation grid was not in contact with the patient skin in the treatment region but the bolus was attached outside the grid resulting in an air gap behind the bolus. Such an air gap can affect dose and dose distribution [1]. The aim of the current investigation is to evaluate the effects of an air gap behind a bolus on dose and dose distribution characteristics.

Material and Methods

Three electron beam energies of an Elekta medical linear accelerator were used: The lowest and the highest available energy as well as one between (6, 10, 20MeV). The applicator (closed walls, 12x8cm^2, 96cm distance from focus to applicator end) is the standard applicator for electron treatment in the neck region at the USB. A typical asymmetrical lead insert (4x8cm^2) was used (Fig 1). The tissue equivalent bolus (Superflab, Mick Radio-Nuclear Instruments, USA; thickness 1cm, 1.02 g/cm^3) was attached either in front or behind an air gap (2, 4cm) with the same thermo plast grid (Posticast, Sinmed BV, Netherlands) as used for head fixation. Percent depth dose (PDD), dose profiles, and relative dose were determined in a water phantom (MP3, PTW, Germany).

Results

Depth of maximum dose in the unblocked central field axis was nearly unaffected by the air gap and the position of the bolus (front, behind). The same is valid for the 50% field width in the depth of the central beam maximum. In contrast, dose in the central field axis was reduced up to 30% (Fig 2) with the bolus in front of the air gap compared to the setting with the bolus behind the air gap. Furthermore, penumbra broadened clearly when the bolus was placed in front of the air gap (Fig 3). Both dose reduction and penumbra broadening are more expressed at lower energies and larger air gaps.

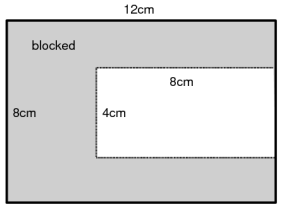

Fig 1: Scheme of the lead insert which is typically for the use in the neck region at the USB.

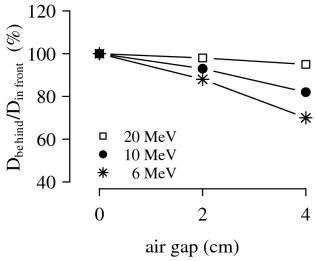

Fig 2: Relative dose in the center field axis with bolus placed in front of the air gap and behind.

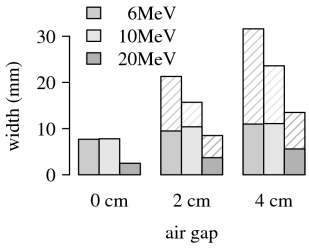

Fig 3: Penumbra width with bolus behind (filled) and in front (total height) of different air gap distances.

Discussion

Even if PDD did not change remarkable due to the position of the bolus, dose decreased markedly at lower energies when the bolus is placed in front of the air gap instead behind. Furthermore a huge increase of the penumbra width was observed. The results show again how sensitive dose and dose distribution can be to small changes of the settings.

References

[1] Sharma SC, Johnson MW Surface dose perturbation due to air gap between patient and bolus for electron beams. *Med Phys*. (1993) 20:377-8.