Is there a dosimetric advantage of using 2.5 MV over 6 MV photons for stereotactic radiosurgerye

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INTRODUCTION

Stereotactic radiosurgery (SRS) was developed decades ago to ablate malignant and non-malignant structures in the cranial vault using small photon fields in a few fractions [1-2]. SRS delivers a very high dose to a small target. It relies on very small field sizes on the order of a few millimeters to ablate lesions and spare normal structures. It is known that the beam geometrical penumbra is realtered to the electron ranges. These electrons are produced from megavoltage photon beams. The higher the photon beam energy the larger the electron range. Therefore the lower phone beam energy may have advantage in producing sharp dose fall off thus minimizing the dose to surrounding brain tissue. The 6 MV photon beam is most often utilized as it is widely available. There is an interest in lower photon energy beams for SRS because their potential to produce a sharper dose fall off.

It is difficult to quantify the dose to surrounding organs at risk by experimental methods especially for small circular fields used in SRS. The Monte Carlo simulations are capable of quantifying the dose differences between using different photon beams for a same treatment plan.

AIM

Since the sharp dose fall off is essential for using small circular fields in SRS we will use a smallest circular field to evaluate if there is a advantage using lower energy photon beams. This study aims to provide a dosimetric comparison to demonstrate if there is an advantage of using 2.5 MV over 6 MV photons for thalamotomy treatment using a 4 mm cone beams.

METHOD

Two beam investigated in this study are a 2.5 MV beam which is produced from Varian TrueBeam for imaging [3-5] and a 6 MV from a Varian TX accelerator.

The EGSnrc [6] Monte Carlo simulation codes, BEAM/DOSXYZ [7-8], were used to simulate 2.5 MV form a Varian TrueBeam and 6 MV beams from a Varian TX accelerator. In the Monte Carlos simulations of generating the circular beams, the same EGSnrc [6] parameter settings were used [9]: AE = ECUT = 0.521 MeV, AP = PCUT = 0.010 MeV. The 2.5 MV beam is a flattening-filter beam produced by electrons hitting a thin copper target and its beam characteristics have been reported [5]. The details of the incident beams including cone accessory were simulated and accuracy of the simulation has been validated against measurements[9-10]. The dose calculations were based on a realistic treatment plan for treatment delivering over a prescribed dose of 145 Gy using a 6 MV (4 mm cone) beam with 21 arcs. The dose calculations were repeated with a 2.5 MV beam with the same cone and delivery arcs to achieve the same target dose prescription.

RESULTS

For the same maximum dose and target coverage for a patient treatment plan that has 21 arcs using 4 mm cone and deliverers 15000 cGy prescribed dose, Figure 1a and 1b compare dose distributions in color-wash at iso-center in axial, coronal and sagittal and planes by using a 6 MV and a 2.5 MV beam respectively. Note the dose color wash scales are from 300 cGy to 15200 cGy. It can be visually seen that the area of dose (300 cGy) is larger for using 6 MV beam than that of using 2.5 MV.

The dose to organs at risk are presented in Figure 2 by using dose-volume histogram (DVH) plots. It is seen that a significant reductions of dose to 50% of the volume of brainstem and chiasm were obtained for 2.5 MV beams comparing to 6 MV beams. Notes about graphs…

Figure 1a

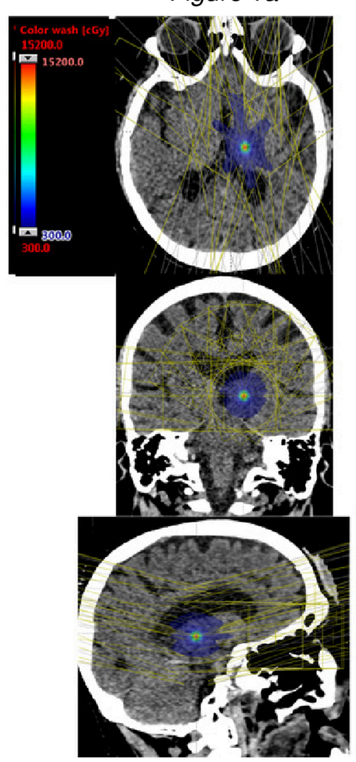


Figure 1b

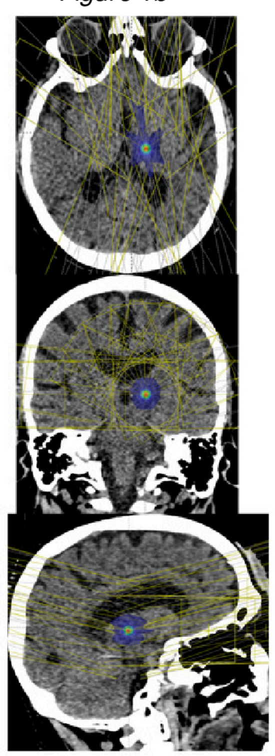
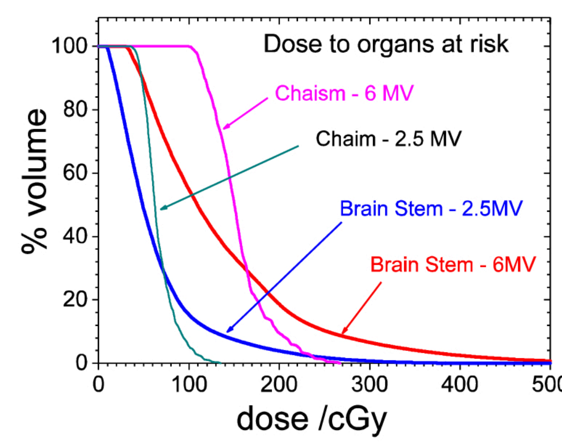


Figure 2



DISCUSSIONS

The 2.5 MV beam from Varian TrueBeam is developed for use in imaging guidance. Its dose rate is only 60 MU per minute. In order to be used for therapy purpose the dose rate will need to be increased by a factor of 10-20 to be viable in clinical practice.

CONCLUSIONS

A significant reduced dose to organ-at-risks can be achieved by a 2.5 MV beam while providing same target dose. There is a clear dosimetric advantage of using 2.5 MV over 6 MV photons for stereotactic radiosurgery. The current 2.5 MV beam is for imaging and observed significant dosimetric benefit should encourage manufactures to develop lower energy photons for therapy treatment using LINAC-based radiosurgery system.

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