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# Evaluation of Dose to Embryo for Prospective Palliative Spine Treatment of a Pregnant Patient

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## ABSTRACT

**Objective:** this study evaluates allowed treatment dose for a 3D treatment of a spinal lesion for a pregnant patient.

**Methods:** measurements were done using in a solid water phantom. Treatment was modeled as AP/PA half beam and distance between the fetus and the treatment area was varied. 0.1 Gy was taken as the maximum dose to fetus based on NCRP 174. 6MV, 6MV FFF and 10MV energies were tested for TrueBeam, Edge and Infinity Agility.

**Results:** all attenuation curves have showed similar trend, with the linear trend for attenuation in 2.5cm – 18 cm range and quadratic growth in 20-35 cm range with significantly steeper slope. The dose decrease at 20cm was 300-400 depending on delivery system.

**Conclusion:** embryo dose limit is achievable for targets 15cm+ away from the embryo.

## INTRODUCTION

The purpose of this study is to evaluate allowed treatment dose for a palliative treatment of spinal lesion of a pregnant patient. NCRP report 174 recommends the limit of a total dose to embryo of 0.1 Gy during a course of radiation treatment. Given this small allowed dose, we performed beam phantom scatter measurements of doses away from the treatment area and compare to predictions obtained from Eclipse treatment planning system.

## METHODS AND MATERIALS

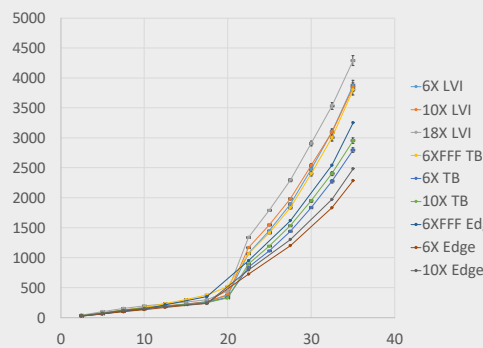
Phantom measurements were obtained in solid water platform mimicking the geometrical dimensions of the prospective patient (30cm x 21 cm x 60cm). Treatment plan was created in the TPS for a treatment of a single vertebrae using 2 opposing half beams (to reduce the divergence in the direction of the embryo) with the field size of 2.5cm x 8cm. 0.6cc PTW Farmer chamber was placed at 11cm depth at a distance from the field proximal edge at 2.5cm increments (2.5cm – 35cm range). The attenuation coefficient, the ratio of field center dose (prescription dose) to the out of field scatter at each given point was measured for 3 different linear accelerator systems – Varian TrueBeam, Varian Edge HD MLC and Elekta Infinity. The scatter curves were obtained for 3 beam energies 6x, 6xFFF and 10x. The scatter to prescription dose was also calculated in Varian Eclipse ver. 15.6 for comparison.

## RESULTS

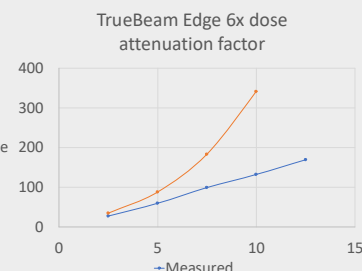
Eclipse TPS had limited success in reproducing scatter data beyond 2.5cm distance from the fields edge and the calculated scatter defaulted to zero for more than 10cm distances, therefore its applications are not practicable for evaluation of doses to an embryo. All measured attenuation curves shows similar trend, with the linear trend for attenuation in 2.5cm – 18 cm range and quadratic growth in 20-35 cm range with significantly steeper slope. The attenuation (prescription dose to dose at the fetus) at 20cm was 300-400 depending on delivery system.

## DISCUSSION

Eclipse TPS had limited success in reproducing scatter data beyond 2.5cm distance from the fields edge and the calculated scatter defaulted to zero for more than 10cm distances, therefore its applications are not practicable for evaluation of doses to an embryo. All measured attenuation curves shown similar trend, with linear trend for attenuation in 2.5cm – 17.5cm range and quadratic growth in 20-35cm range with significantly steeper slope. The attenuation at 20cm was 300-400 depending on delivery system.

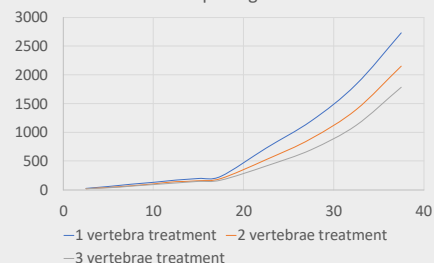


**Chart 1.** Dose attenuation vs distance from the field edge (cm). Attenuation is defined as the ratio of dose at measuring point to the dose at field center at patient midline (prescription point). As seen from the plot, the attenuation could be well approximated by a straight line in the range of 2.5 cm – 17.5 cm for TrueBeam Edge and in the range of 2.5 cm – 20 cm for Varian TrueBeam and Elekta Infinity/Agility. An attenuation of 300-500 could be achieved at 15-20 cm to deliver palliative dose (30 Gy) to tumor while keeping embryo dose below 0.1 Gy. Data is shown for TrueBeam (TB), Edge and Infinity (LVI) with Agility MLC.



**Chart 2.** Attenuation factor vs distance from the field edge for TrueBeam Edge 6x beam. Measured values are significantly lower than treatment planning estimations for attenuation (Eclipse version 15.6 AAA or Acuros). TPS estimates scatter doses as zero at distances exceeding 10cm away from the field edge thus making TPS unusable for embryo dose prediction at this range.

## Attenuation Factor for different field opening



**Chart 1.** Dose attenuation vs. distance for different spinal field openings – one vertebrae field has the highest attenuation at a given distance, when 2 or 3 vertebrae treatment is associated with a higher dose at a given point. Dose to a point for a 2 vertebrae treatment (5 cm height 8 cm width) is approximately higher than the dose from a 1 vertebra treatment (2.5 cm height 8 cm width) by 25%.



**Figure 1.** Phantom setup.

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## CONCLUSIONS

Based on this phantom review NCRP 174 embryo dose limit is achievable for targets 15cm+ away from the embryo. TPS dose predictions are not available at this range.

## REFERENCES

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