Measurement of Fetal Dose for Pregnant Patients Undergoing Emergency Treatment of Lung Cancer

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INTRODUCTION

TG-36 recommends that the dose delivered to a fetus be restricted to a maximum of 10 cGy to avoid adverse side effects. There is limited data on fetal dose in the literature to support decision-making when treating pregnant patients. For example, when generating a 3D plan, head leakage and internal scatter will contribute to fetal dose, but there is a lack of recommendations to support an ideal beam arrangement to limit those factors. To reduce the dose scattered outside of the treatment field, the beam can be collimated using the jaws to generate a treatment field of identical dimensions but varying in scattering capabilities. This study is based on a case of an emergency treatment of a pregnant patient with lung cancer, where the clinical decision was informed by experimental results prior to treatment.

AIM

To measure the fetal dose delivered to pregnant lung cancer patients using AP/PA fields with different beam divergences for consideration of phantom scatter and different distances from the Linac head for evaluation of head leakage.

METHODS AND MATERIALS

Three 6 MV AP/PA plans were created to test three levels of head leakage and three levels of beam divergence (contributing to internal scatter). These plans delivered 800 cGy in 1 fraction with a field size of 18.6 cm x 12.5 cm and 90° collimator rotation to further reduce head leakage.
The inferior half-beam block (IHB) plan had the inferior jaw (closest to the fetus) blocked, resulting in the smallest divergence and largest amount of head leakage. The symmetric beams (symm) plan had symmetric contribution from the upper and lower jaw, resulting in a medium amount of divergence and head leakage. The superior half-beam block (SHB) plan had the upper jaw blocked, resulting in the largest divergence and the lowest amount of head leakage.
The peripheral dose (PD) was measured with a RANDO phantom and solid water at depths of 5 cm and 10 cm using an ionization chamber at 5 cm, 10 cm, 15 cm, 20 cm, and 25 cm away from the field edge.

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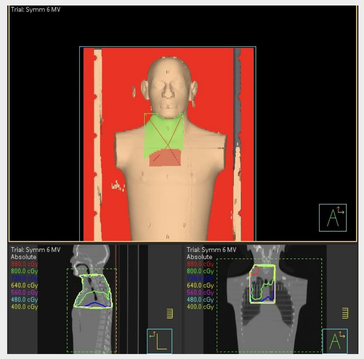

Figure 1. Symm plan on Pinnacle.

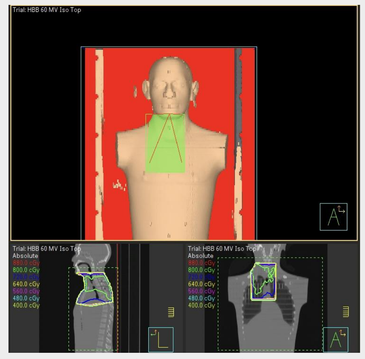

Figure 2. SHB plan on Pinnacle.

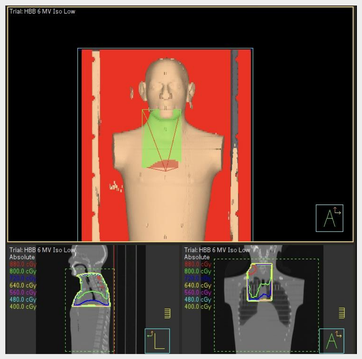

Figure 3. IHB plan on Pinnacle.

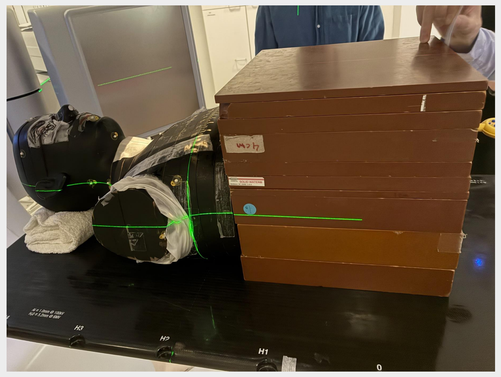

Figure 4. Set-up for measuring peripheral dose with RANDO and solid water using ion chamber.

	Dose at Distance from Field Edge (cGy)				
	5 cm	10 cm	15 cm	20 cm	25 cm
IHB	16.25	9.72	2.48	2.63	1.28
Symm	23.03	12.28	4.94	1.93	1.44
SHB	19.47	9.88	4.38	1.64	1.15

Table 1. Measured dose in cGy by each plan at 5 cm depth for various distances from the field edge.

	Dose at Distance from Field Edge (cGy)				
	5 cm	10 cm	15 cm	20 cm	25 cm
IHB	17.17	10.19	5.14	2.59	1.25
Symm	22.60	12.64	4.68	1.93	1.43
SHB	20.92	10.08	4.24	2.15	1.14

Table 2. Measured dose in cGy by each plan at 10 cm depth for various distances from the field edge.

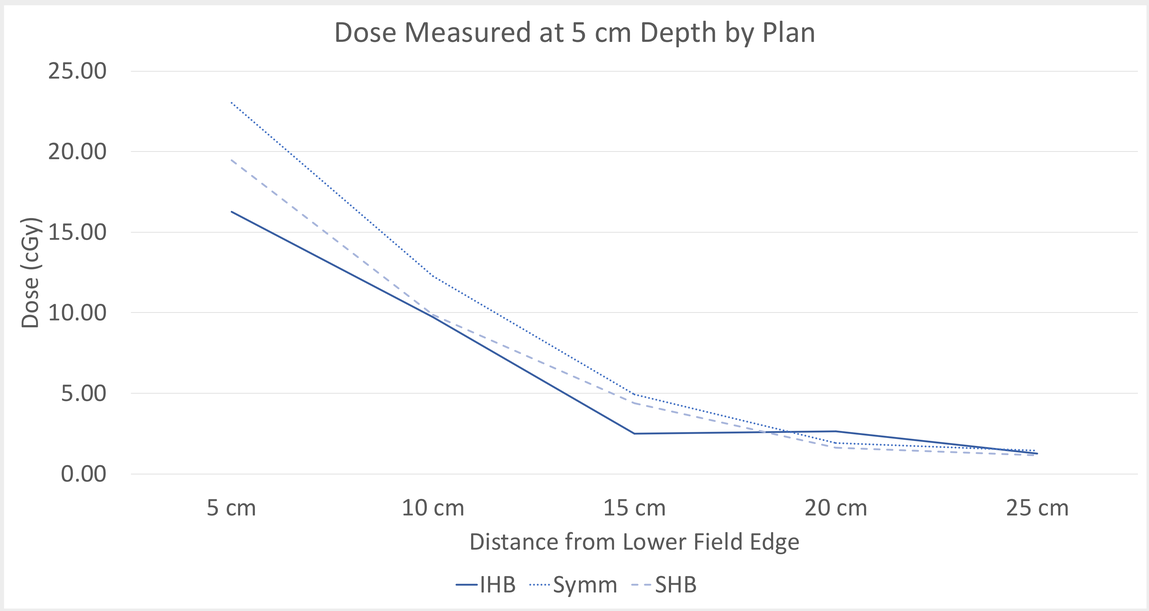

Figure 5. Dose in cGy by each plan at 5 cm depth for various distances from the field edge.

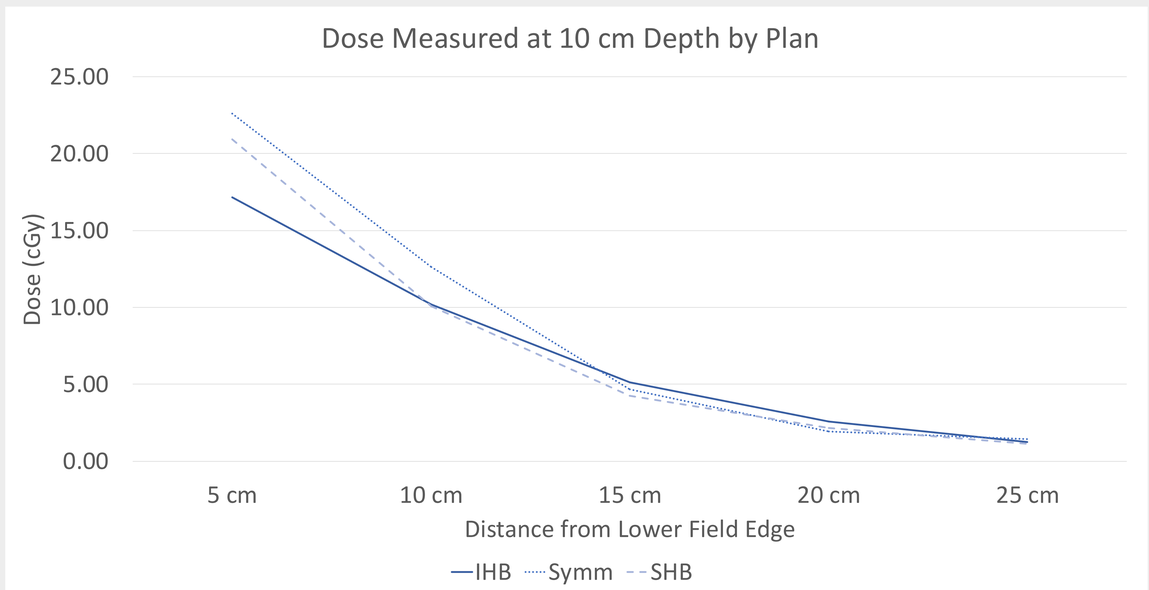

Figure 6. Dose in cGy by each plan at 10 cm depth for various distances from the field edge.

RESULTS

At a depth of 5 cm, the peripheral dose measured at 5 cm, 10 cm, 15 cm, 20 cm, and 25 cm were 16.3 cGy, 9.7 cGy, 2.5cGy, 2.6 cGy, and 1.3 cGy with the IHB plan, 23 cGy, 12.3 cGy, 4.9 cGy, 1.9 cGy, and 1.4 cGy with the symm plan, and 19.5 cGy, 9.9 cGy, 4.4 cGy, 1.6 cGy, and 1.2 cGy with the SHB plan.
At a depth of 10 cm, the peripheral dose measured at 5 cm, 10 cm, 15 cm, 20 cm, and 25 cm were 17.2 cGy, 10.2 cGy, 5.1cGy, 2.6 cGy, and 1.3 cGy with the IHB plan, 22.7 cGy, 12.6 cGy, 4.7 cGy, 1.9 cGy, and 1.4 cGy with the symm plan, and 20.9 cGy, 10.1 cGy, 4.2 cGy, 2.2 cGy, and 1.1 cGy with the SHB plan.

DISCUSSION

The doses measured at the varying distances from the field edge were comparable at 5 cm and 10 cm depth, indicating that peripheral dose is confounded by internal scatter and head leakage. Although peripheral doses were measured at 5 cm, 10 cm, and 15 cm distances from the field edge for each plan, they are an overestimation of the dose that could be delivered to a fetus, which would likely lie 20-30 cm away from the field edge in the case of a lung cancer treatment. Additionally, at those distances, the variation between the doses delivered by each plan was less than a centigray. Each measurement was repeated twice; however, when comparing such small dose differences, the variation can be due to noise. In the future, this experiment may be repeated with a larger dose delivered by the plan to the phantom to magnify any potential differences between head leakage and internal scatter delivered by each plan.

CONCLUSION

All plans are safe for treatment of pregnant patients when the fetus is greater than 15 cm away from the field edge, and all measured doses were below the 10 cGy limit recommended by TG-36 for fetal dose. When the distance was <15 cm from the field edge, the IHB plan contributed the lowest dose to the fetus. We recommend conducting measurements to determine ideal beam arrangements for pregnant patients.

REFERENCES

Stovall M, Blackwell CR, Cundiff J, et al. Fetal dose from radiotherapy with photon beams: report of AAPM Radiation Therapy Committee Task Group No. 36. Med Phys. 1995;22(1):63–82.

Owrangi AM, Roberts DA, Covington EL, Hayman JA, Masi KM, Lee C, Moran JM, Prisciandaro JI. Revisiting fetal dose during radiation therapy: evaluating treatment techniques and a custom shield. J Appl Clin Med Phys. 2016 Sep 8;17(5):34-46.