ABSTRACT FINAL ID: 2095;

TITLE:
Helical Tomotherapy SBRT for Liver Metastases: Recommendations for Potential Candidates Based on Tumor Size and Location.

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ABSTRACT BODY:

**Purpose/Objective:** Stereotactic Body Radiotherapy (SBRT) has been shown to be effective for local control of metastatic liver tumors. Several groups have shown that liver SBRT is well tolerated with schedules ranging from 20-40 Gy in 2-4 fractions or 14-26 Gy in 1 fraction. Reported side effects include transient fever, nausea, and vomiting, and mildly symptomatic grade 1 and 2 radiation-induced liver dysfunction. Currently Phase II trials are examining SBRT of liver with doses of 60 Gy in 3 fractions. HiArt Helical TomoTherapy is a treatment unit which delivers co-planar helical IMRT that is capable of image guided SBRT. In order to determine if Helical Tomotherapy could be used for SBRT of liver tumors we performed inverse treatment planning and analyzed the dosimetry for multiple liver GTV volumes in several representative anatomic locations. The purpose of this study was to develop objective criteria for defining the suitability of liver tumors for Helical Tomotherapy SBRT based on tumor size and proximity to normal organs.

**Materials/Methods:** Hypothetical liver lesions were created using an existing CT scan. These GTV lesions were of sizes from 1 to 6 cm in diameter with GTV volumes ranging from 0.8 cm$^3$ to 84.8 cm$^3$. The liver was subdivided into the left lobe, right upper lobe, and right lower lobe and the GTV structures were placed in each of these liver subdivisions. A 5mm radial expansion and a 10mm craniocaudal expansion of the GTV was used to create the PTV. Treatment plans were generated using the Helical Tomotherapy inverse planning system with a minimum PTV dose of 60 Gy in 3 fractions covering at least 95% of the PTV. We chose to use the 25 mm jaw width after preliminary calculations revealed that the 10 mm jaw width would require over 2 hours to deliver a 20 Gy dose even for small tumors. Normal organ constraints were as follows: 30 Gy maximum dose to the heart, stomach, and small intestine; 18 Gy maximum dose to the spinal cord; 700 cc of normal liver to receive < 15 Gy; 35% of the kidneys to receive < 15 Gy. For a plan to be considered acceptable all of the target and normal organ constraints had to be met.

**Results:** Analysis of the dosimetry revealed differences in limitations to treatment by liver subdivision. For the left lobe, proximity to the heart and stomach limited the size of lesion with acceptable dosimetry to 3 cm. For the right upper lobe, the proximity to the heart and liver dose volume constraints resulted in a maximum treatable tumor size of 5 cm. A tumor size of 5 cm was limiting for the right lower lobe, again due to normal liver dose volume constraints; however proximity to the small bowel was also a limiting constraint. Dose inhomogeneity was acceptable, with the maximum doses ranging from 62 Gy - 77 Gy. Calculated treatment times varied between 58-85 minutes.

**Conclusions:** The HiArt Helical Tomotherapy system is capable of performing high dose liver SBRT that meets the specified target and normal organ constraints. This study provides broad initial screening eligibility criteria for patients with hepatic metastases who may be suitable for TomoTherapy-based liver SBRT. These guidelines are: for left lobe tumors; a GTV of $\leq$ 3 cm in diameter and a GTV that is at least 13 mm from the heart and 8 mm from the stomach; for right upper lobe tumors; a GTV of $\leq$ 5 cm in diameter that is at least 13 mm from the heart; for right lower lobe tumors; a GTV of $\leq$ 5 cm in diameter that is at least 8 mm from small bowel.

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