CyberKnife Stereotactic Body Radiation Therapy for Patients with Heavily Pre-Treated Liver Metastases and Liver Tumors

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Objectives: We present our early experience with CyberKnife stereotactic body radiation therapy (SBRT) in a heavily pretreated group of patients with liver metastases and primary liver tumors.

Methods: From October 2007 to June 2009, 48 patients were treated at the Philadelphia CyberKnife Center for liver metastases or primary liver tumors. Triple phase contrast enhanced CT was obtained for treatment planning. Liver windows with contrast were used for contouring the clinical tumor volume (CTV). In addition to the liver tumor/metastases (CTV), normal tissues in proximity to the tumor were contoured including the bowel, heart, and kidney. The planning target volume (PTV) was defined by a uniform 5 mm expansion of the CTV. If necessary, due to normal tissue proximity, margins were reduced to 3 mm or less. Dose was generally prescribed to the 60-80% isodose line to cover 95% of the PTV with the prescribed dose. The goal of treatment was to achieve a high dose to the liver tumor while sparing at least 700 cc of liver from doses of radiation above 15 Gy.

Results: Thirty patients with 40 discrete lesions (1-4 tumors per patient) were treated with an ablative dose of radiation (BED ≥ 79.2 Gy_{10}) and are the subject of this report. The majority of patients (n=23) were treated for metastatic cancer with the remainder being primary liver tumors, either cholangiocarcinoma (n=4) or hepatocellular carcinoma (n=3). Eighty-seven percent of patients had prior systemic chemotherapy with a median time from diagnosis to radiosurgery treatment of 24 months; 37% of patients had prior liver-directed therapy. At a median follow-up of 15 months (range 4-34 months), 9 (30%) of the thirty patients had documented local failure. A dose response was demonstrated; 40% of tumors treated with a BED $\leq$ 100 Gy_{10} (8/20) suffered a local failure compared with 20% local failures for those tumors receiving a BED > 100 Gy_{10} (4/20). The Liver-to-Tumor Ratio (LTR) was calculated to quantify the inter-relationship between the liver and tumor volume. Patients with local failure had a lower median LTR of 15.0 (range 4.1-46.3) in comparison to those with local control who had a median LTR of 24.93 (range 5.25-199.732). Twenty-four of 30 patients (80%) had distant progression of disease at last follow-up, as distant failure was the most common type of failure. Crude overall survival for all 30 patients was 56.7% (17/30) with a median survival of 23 months from treatment and 72 months from diagnosis. To date, none of the patients treated have experienced any severe adverse effects.

Conclusions: Despite the heavily pretreated nature of these patients, CyberKnife SBRT was well tolerated with excellent local control rates if adequate doses (BED>100 Gy_{10}) are used. Local control was a function of increased dose and LTR. Therefore patients should be referred early with the smallest possible tumor volume for optimal local control. Median survival for this group of patients is excellent despite metastatic disease in the majority. Protocols for SBRT should include chemotherapy if patterns of failure are to be adequately addressed.

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