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Perspective

The Utility of a Robotic Stereotactic Radiation Treatment System to Treat Primary and Metastatic Liver Tumors

Rex Cheung*

Flushing Radiation Oncology CyberKnife Center, USA

***Corresponding author:** Rex Cheung, Flushing Radiation Oncology CyberKnife Center, 40-20 Main Street, 4th Floor, Flushing, NY 11354, USA, Email: rcheung@flushingros.com

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Keywords

Re-irradiation; Robotic; Stereotactic; CyberKnife; Liver cancers

Background

Liver tumors pose a particular challenge to radiation oncologists. The critical organs, kidney, healthy liver, duodenum, small bowel, and spinal cord are relatively radiation sensitive [1]. This may limit the ability of conventional 3-dimensional radiotherapy (3D-CRT) to treat these liver tumors to a desired dose. Stereotactic body radiotherapy (SBRT), when the fractionation scheme is 1-5 fractions, has increasing been used to treat liver tumors [2].

The major advance in modern stereotactic radiation treatment machines includes the ability of the machines to identify anatomical landmarks or fiducial markers and track them accurately and efficiently with on-board imaging. This stereotaxy may improve the outcomes and limit the toxicities. For example, cyberknife (Accuray Inc., Sunnyvale, CA) robotic stereotactic radiation system [3] uses skull tracking, Xsight spine tracking, XSight lung tracking for peripheral lesions, implanted fiducial tracking, and Synchrony real-time respiratory tracking system. With the many degrees of freedom of the robotic arm, it could deliver very high dose efficiently and safely with active tracking. Other advanced systems may also have similar capacities [4-6]. This paper is a part of a series exploring the utility of stereotactic radiotherapy machines in treating challenging cases [7].

Biologic Effective Dose (BED) [8] of 100 Gy for $\alpha/\beta = 10$ has been found to be needed to treat the hepatocellular carcinoma (HCC) and hepatic metastasis [9]. A typical regime of 15 Gy × 3 over 10-12 days (Equivalent Dose at 2-Gy (EQD2) [8] = 112.5 Gy [10]) has led to a local control rate of about 80% at 1-2 years in both cases [9-11]. SBRT has been used as an alternative for transarterial chemoembolization (TACE), surgical resection and radiofrequency ablation (RFA) [10]. SBRT is well tolerated even in heavily pretreated liver cancer patients [9]. SBRT could also be used as a bridge to curative liver transplantation [12].

Treatment planning

Contrast CT with liver window could be used for contouring gross tumor volume (GTV), in general gold fiducials are placed [9,11] and respiratory tracking could be used during treatment. The planning target volume (PTV) margin used could be as tight at 1.5 – 5 mm [9,11] when cyberknife is used. Among the surrounding normal tissues, the liver, stomach and duodenum are particularly sensitive and their toxicities may be dose limiting [11]. More than 700 c.c. of uninvolved liver should get less than 15 Gy to maintain normal liver function [9,11].

A hypothetical clinical scenario

A hypothetical case is used here to illustrate the clinical decision making process. Suppose the patient is a 50 years old man, with an alpha fetoprotein of 100ng/ml, and has a Child-Turcotte-Pugh (CPA) Class A liver function. His HCC has been treated with TACE and RFA in the past. Now he has a recurring 3 cm HCC. What is the SBRT radiation treatment strategy supported by the literature [9-11] ?

The prognostic value of performance status has consistently been found to be important in selecting which patients will benefit from liver SBRT [13], and liver function and dose are particularly important prognostic factors [9-11]. This patient would have a high probability of benefitting from liver SBRT. A 15 Gy × 3 fractions dose-fraction may be used in this case [9,11]. With this dose, for a 3 cm or less recurrent HCC as in this putative case, or for a similar size liver metastasis, the 1-2 year local control is expected to be higher than about 80% [11].

Conclusion

SBRT of primary and metastatic tumors are safe and effective. It should be considered among the treatment strategies for liver tumors.

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