BRACHYTHERAPY

Brachytherapy 14 (2015) 537−542

Dosimetric comparison of brachyablation and stereotactic ablative body radiotherapy in the treatment of liver metastasis

J. Daniel Pennington[1], Sang June Park[1], Narine Abgaryan[1], Robyn Banerjee[1], Percy P. Lee[1], Christopher Loh[2], Edward Lee[2], D. Jeffrey Demanes[1], Mitchell Kamrava[1,*]

[1]*Department of Radiation Oncology, UCLA Medical Center, Los Angeles, CA*
[2]*Department of Interventional Radiology, UCLA Medical Center, Los Angeles, CA*

ABSTRACT

PURPOSE: We compared the dosimetry of brachyablation (BA) and stereotactic ablative radiotherapy (SABR) in the treatment of liver metastases.

METHODS AND MATERIALS: Treatment plans for 10 consecutive liver metastasis patients, treated with SABR, were replanned for BA. BA treatment was planned using five 12 Gy fractions to the same planning target volume (PTV) used for SABR. Dosimetric parameters were compared using a Student's paired *t* test.

RESULTS AND CONCLUSIONS: BA and SABR plans had similar mean volume receiving 100% of the prescribed dose (94.1% vs. 93.9% of PTV, $p = 0.8$). Mean volume receiving 150% of the prescribed dose for BA was 63.6%, whereas for SABR it was 0. The minimum dose to the PTV was 65.8% for BA, whereas for SABR it was 87.4% ($p = 0.0002$).

Liver volume receiving ≥15 Gy was similar for BA and SABR (278 vs. 256 cc, $p = 0.3$). Small bowel mean dose, as percent prescription dose, was higher for BA (10.8% vs. 7.1%, $p = 0.006$). Stomach mean dose was similar (4.9% vs. 4.8% of prescription dose, $p = 0.98$). Right kidney mean dose was greater for BA (6.7% vs. 4.2%, $p = 0.07$).

BA leads to a higher target dose, similar dose to organs at risk, but potentially with lower target coverage compared with SABR. Further work is needed to determine ideal suitability for mono vs. combination therapy with this approach.

Keywords: Stereotactic body radiotherapy; SABR; Brachyablation; Liver metastasis; Image guided brachytherapy

Introduction

A variety of treatment modalities are available for managing oligometastatic liver lesions. They include surgery, multiple ablative modalities (high-intensity frequency ultrasound, radiofrequency ablation, and cryotherapy), chemotherapy, and radiation therapy.

Advances in radiation treatment delivery and imaging have expanded the role of external beam radiation therapy to include stereotactic ablative radiotherapy (SABR). SABR for oligometastatic liver lesions has a mature clinical experience, with multiple studies demonstrating considerable promise (1). The successful delivery of this treatment relies on strict patient immobilization and accounting for organ motion (four-dimensional CT simulation, respiratory gating, and/or fiducial marker seed localization).

Brachyablation (BA) represents an advance in brachytherapy treatment delivery and through collaboration with interventional radiology allows brachytherapy catheters to be inserted directly into the tumor. By having catheters directly placed into the target, a smaller volume can be treated compared with SABR, as one does not need to account for a planning target volume (PTV). The dose heterogeneity of brachytherapy can also allow for dose escalation, which may be advantageous in larger targets.

Although several series of patients treated with BA have been published, these articles neither do fully characterize the specific advantages or disadvantages of this technique nor do address how or why this technique compliments SABR. In our dosimetric analysis, we provide the first comparison of

Received 17 February 2015; received in revised form 19 March 2015; accepted 6 April 2015.

The authors declare no conflict of interest.

* Corresponding author. Department of Radiation Oncology, 200 UCLA Medical Plaza, Suite B265, Los Angeles, CA 90095-6951. Tel.: +1-310-825-9775; fax: +1-310-794-9795.

E-mail address: MKamrava@mednet.ucla.edu (M. Kamrava).

1538-4721/$ - see front matter
http://dx.doi.org/10.1016/j.brachy.2015.04.002

these technologies and suggest directions for future investigation.

Methods and materials

Ten consecutive patients treated with SABR (by PPL) for hepatic metastases were selected for comparative BA dosimetric analysis. Planning used identical structure sets and prescription (12 Gy × five fractions) for each analysis. An interventional radiologist (CL) selected the number and trajectory of catheters for virtual insertion into the target lesion (Fig. 1). A treatment plan was created for each patient (by SJP) using high-dose-rate brachytherapy planning software (Oncentra Masterplan, version 4.3; Nucletron, Veenendaal, The Netherlands) to simulate BA treatment of these lesions and reviewed by a radiation oncologist with brachytherapy expertise (MK). Inverse planning simulated annealing was used to come up with an initial plan followed by manual graphical optimization. The planning goal was to match the PTV receiving 100% of the prescribed dose to the SABR plan.

Planning was for high-dose-rate brachytherapy using an iridium-192 afterloader. CT simulation would follow catheter insertion. After the catheters are secured in place using a drain tie, they would be marked and checked for migration before treatment. There would be a 6 hour treatment interval between fractions. CT simulation would need to be performed before each subsequent fraction to assess catheter displacement.

Dose–volume histograms were generated for each plan and used for comparative analysis. Comparison was by paired two-tailed Student's t test. We compared target coverage parameters (volume receiving 100% of the prescribed dose [$V_{100\%}$]; volume receiving 150% of the prescription dose [$V_{150\%}$]; percentage of the prescription dose covering 90% of the volume of the PTV; average, mean, and minimum percentage of the prescription dose), dose falloff (ratio of the volume receiving 50% of the prescription dose to the volume of the PTV [$R_{50\%}$]), and dose to organs at risk (liver volume receiving 15 Gy or more and mean dose to small bowel, stomach, and right kidney). For one of the 10 patients, we were not able to develop a feasible BA plan because the tumor target was located in a position that was safe, and adequate access with catheters was not felt to be possible. This patient was excluded from further analysis.

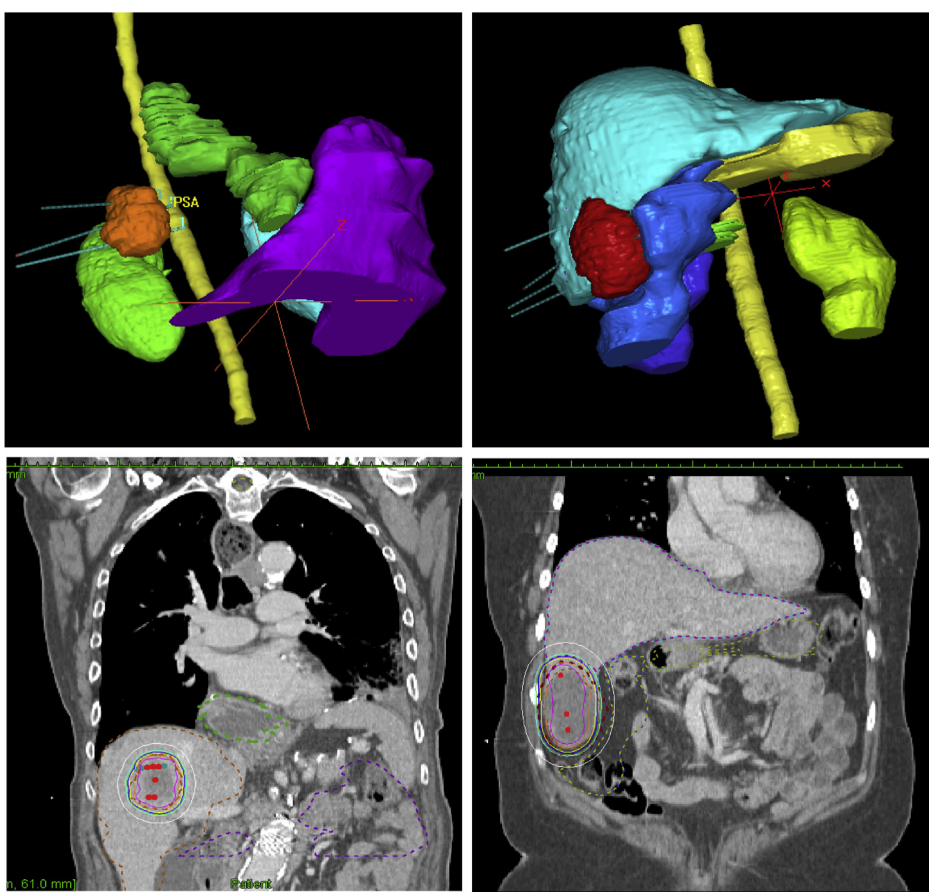

Fig. 1. Examples of two brachyablation (BA) plans are shown. Patients treated with stereotactic ablative radiotherapy were replanned for BA treatment using virtual catheters placed into the lesion. Catheters are pictured in relation to tumor and organs at risk.