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Feasibility of Biology-Guided Radiotherapy for Liver Metastases Using a PET-CT LINAC

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Abstract
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Abstract

Objectives:

SCINTIX biology-guided radiotherapy (BgRT) is a novel radiotherapy modality utilizing fluorodeoxyglucose (FDG) activity on positron emission tomography (PET) imaging performed in real-time to guide radiotherapy beamlets. Two PET metrics, Activity Concentration (AC) and Normalized Target Signal (NTS), need to meet specific thresholds for a tumor to be considered amenable to SCINTIX therapy. This study examines various characteristics of liver metastases (size, volume, ACmean, ACmax) that meet these thresholds to generate a SCINTIX treatment plan.

Methods:

PET/CT image datasets from 10 patients with liver metastases were acquired on a diagnostic PET/CT system. The PET/CT images of the liver lesions were collected on the MIRADA Medical Imaging Software, and the PET was imported on the RefleXion Treatment Planning System (TPS). In the RefleXion TPS, a simulation tool was used to convert the diagnostic PET images into simulated SCINTIX planning PET images accounting for differences in system sensitivity, acquisition time, reconstruction method and geometry between the diagnostic PET/CT system and the PET-linac.
The gross tumor volumes (GTVs) for the liver metastases were contoured using MIRADA Medical Imaging System. Plan tumor volumes (PTVs) and Biology-Tracking Zones (BTZs) which encompass the full range of motion of the GTVs plus a margin were generated by 5 and 10 mm isotropic GTV expansion, respectively. In addition, a background structure BTZ shell created via a 5 mm expanded shell from the BTZ. The mean AC (ACmean) was calculated for each liver metastasis GTV, PTV, BTZ and BTZ shell, and the maximum AC (ACmax) was measured for GTV and BTZ shell on the diagnostic PET images in MIRADA. AC and NTS values were also measured on the simulated RefleXion planning PET images in the RefleXion TPS. The GTV volume, GTV superior-inferior length (SIL), and the PTV's distance to nearest organ at risk (OAR) were recorded in MIRADA for all cases.

Results:

Five patients with 8 measurable lesions passed the RefleXion TPS AC and NTS metrics upon conversion to a simulated RefleXion planning PET and were included in the final analysis. The ACmean for GTVs, PTVs, BTZs and BTZ shells was 19.2 +/- 5.8 kBq/ml, 15.3 +/- 4.7 kBq/ml, 12.7 +/- 3.8 kBq/ml, and 9.5 +/- 3.9 kBq/ml, respectively. The ACmax for the GTVs and BTZ shells was 28.4 +/- 7.9.7 kBq/ml, and 21.1 +/- 6.3 kBq/ml, respectively. The GTV volume, GTV SIL and distance from PTV to nearest OAR was 11.2 +/- 8.5 cc, 2.6 +/- 1.0 cm, and 5.1 +/- 2.4 cm, respectively. The TPS AC and NTS were 12.3 +/- 3.4 kBq/ml and 7.8 +/- 4.1, respectively.

Conclusion(s):

This study characterizes liver metastases tumor volumes, lengths, ACmax, and ACmean on diagnostic PET/CT scans for cases that met the AC and NTS thresholds for SCINTIX BgRT planning on the RefleXion TPS. These results may guide patient selection for future studies on SCINTIX treatment for patients with liver metastases.