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Impact of Data-Driven Respiratory Gating on Pre-Therapeutic Tc99m-MAA-Based SIRT Dose Estimations

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P1956

Aim:

Tc99m-MAA SPECT/CT scans are an essential part of SIRT therapy planning. In addition to extrahepatic shunting, they may be used to estimate dose to healthy and disease tissue. However, respiratory motion imposes quantitative bias on SPECT liver images that may hinder this process.
The aim of this study was to evaluate the extent to which respiratory gating of the planning scan might affect pre-therapy dose calculations.

Methods:

13 datasets from 11 patients injected intraarterially with 97.8±29.3 MBq Tc99m-MAA were acquired with a Symbia T2 SPECT/CT (Siemens Medical Solutions). All patients granted informed consent. 60 views were acquired at 15 sec each, and list-mode data was also available from the system. In addition to ungated projections, fully-automated data-driven respiratory gating was applied to the list-mode data to subdivide it into 5 gates [1]. These 6 datasets were reconstructed using a prototype version of the xSPECT Quant software (20 iterations/1 subset, attenuation and scatter correction, no post-smoothing).
Non-necrotic, hyper-vascularized lesions were located in coregistered MR images, and tumor Volumes of Interest (VOIs) were demarcated on SPECT images using isocontours centered on each focus. Isocontour thresholds were chosen such that the volume of each VOI in the nuclear image matched its corresponding lesion in the MR image. VOIs for normal liver tissue including only lobes to be treated were transferred directly from MR to SPECT.
Prospective dose in tumor and normal liver tissue (TD, LD, respectively) were evaluated for each patient using a partition model [2] and a 50 Gy dose in the therapy volume (tumor + normal). Quantities from the reconstructed gate with the maximum TD/LD ratio were then compared to the ungated values.

Results:

Figure 1 shows coronal slices from one representative patient. Relative to the ungated image (left), clear head/foot motion is visible between gated images at beginning- (center) and end-inspiration (right).
There was no significant difference between LD in gated and ungated reconstructions (p=0.66)(Figure 2, top). However, TD was significantly higher in gated images (p<0.001) by an average of 16±12% (Figure 2, bottom), leading to a significant increase in TD/LD ratio by 15±10% (p<0.001). Increases after respiratory gating ranged from 0 to 32%.

Conclusion:

We found a significant increase in the TD/LD ratio in our gated reconstructions by up to 32%. This indicates that data-driven respiratory gating could allow physicians to more accurately estimate tumor dose while planning a SIRT intervention. Further work must be done to account for necrotic lesions and lung shunting to fully evaluate the effect this information will have on patient management

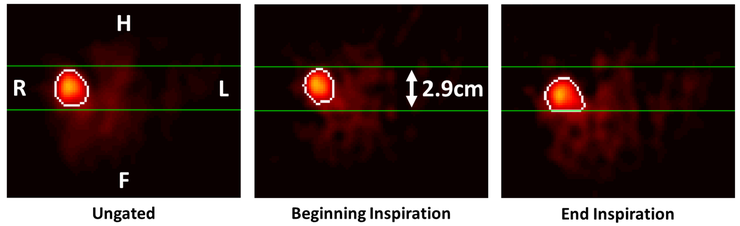

Figure 1. Coronal slices of reconstructed images from representative patient. Ungated image shown on left. Clear head/foot motion visible between beginning inspiration (center) and end inspiration (right). VOI boundaries are demarcated in white.

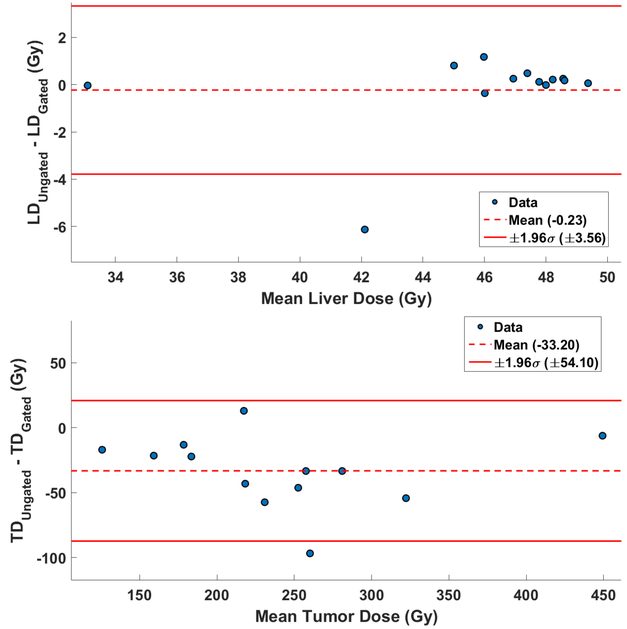

Figure 2. Bland-Altman plots comparing Liver (top) and Tumor (bottom) Doses estimated from gated and ungated reconstructions.

Literature:

[1] Sanders JC, Ritt P, Kuwert T, Vija AH, Hornegger J. Data-driven respiratory signal extraction for SEPCT imaging using laplacian eigenmaps. Paper presented at: IEEE Nuclear Science Symposium and Medical Imaging Conference; November 1-7, 2015; San Diego, CA.
[2] Ho S, Lau WY, Leung TWT, et al. Partition model for estimating radiation doses from yttrium-90 microspheres in treating hepatic tumours. *Eur J Nucl Med*. 1996;23:947-952.

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