Predictive value of dose metrics from ^{99m}Tc-MAA compared to ^{90}Y SPECT/CT in Dosimetry-Guided Personalized SIRT of Hepatocellular Carcinoma

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Background and Objective

Selective internal radiation therapy (SIRT) with ^{90}Y radioembolization aims to selectively irradiate liver tumors by administering radioactive microspheres. To simulate the treatment, a pre-therapy injection of ^{99m}Tc labeled macro-aggregated albumin (Tc-MAA) aims to provide an estimation of the ^{90}Y microspheres biodistribution. However, it is not always the case. In this context, a robust relationship between the delivered and pre-treatment radiation doses is required.

In this work, we aim to investigate the predictive value of dose metrics calculated from Tc-MAA compared to those obtained from ^{90}Y post-therapy SPECT/CT.

Materials and Methods

A total of 48 patients (43 patients with hepatocellular carcinoma (HCC), 4 with metastases, 1 patient with intrahepatic cholangiocarcinoma (ICC)) who underwent ^{90}Y SIRT with glass microspheres were retrospectively included in this study.

SPECT/CT imaging was performed on a Symbia T Series camera after simulation (Tc-MAA) and therapy (Y-90). Treatment planning was designed based on single partition model. Lesion and lobar segmentation were manually performed by a nuclear medicine physician on the diagnostic images (contrast-enhanced CT or MRI). Simulation and therapy SPECT/CT images were registered on the diagnostic images using rigid transformation.

The pipeline is shown in Fig. 1.

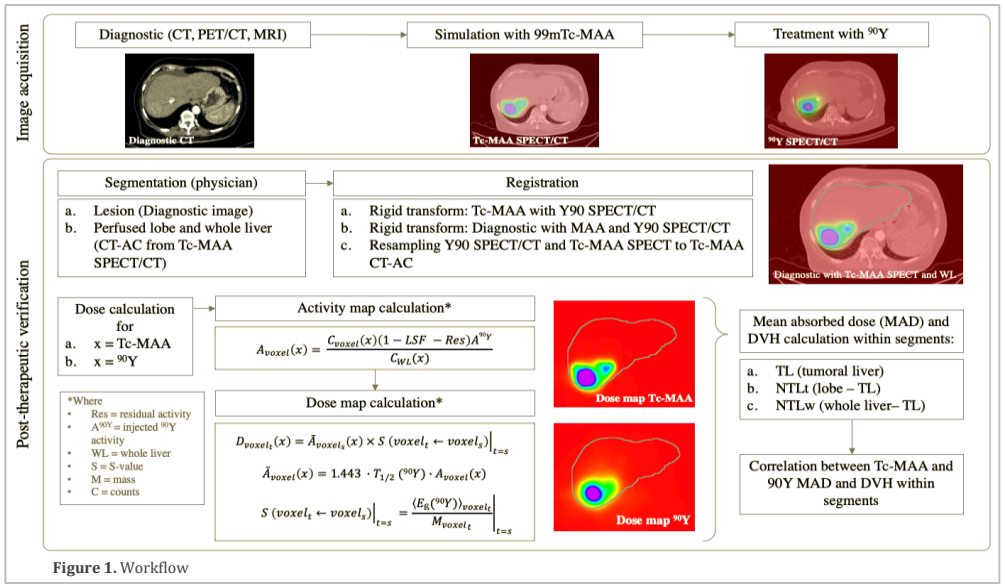

Figure 1. Workflow

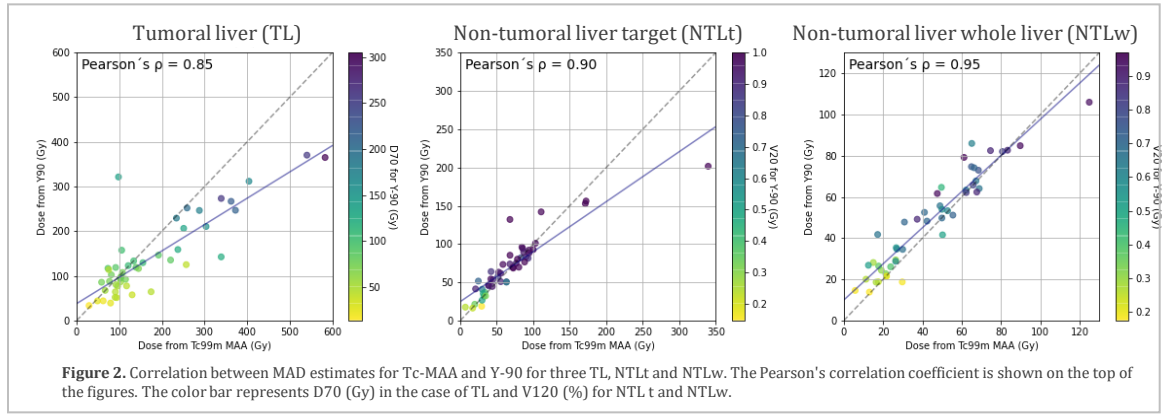

Figure 2. Correlation between MAD estimates for Tc-MAA and Y-90 for three TL, NTLt and NTLw. The Pearson's correlation coefficient is shown on the top of the figures. The color bar represents D70 (Gy) in the case of TL and V120 (%) for NTL t and NTLw.

Consistent with the literature, in NTLt and NTLw, the values of MAD from Tc-MAA and ^{90}Y showed high correlation (0.90, *p-value < 0.001*; and 0.95, *p-value < 0.001*) (Table 1).

D50, D70 and V120 derived from TL DVHs illustrated good agreement between Tc-MAA and ^{90}Y dosimetry (Table 1), but according to Pearson's factor, this correlation is stronger for D70 (0.86, *p-value < 0.001*) than for D50 (0.83, *p-value < 0.001*) and V120 (0.79, *p-value < 0.001*) (Table 1).

3D voxel-level dosimetry based on self-calibration and local energy deposition approach was conducted, where the **mean absorbed dose (MAD)** and **dose volume histograms (DVHs)** were computed for three regions of interest: **tumoral liver (TL)**, **non-tumoral liver target (NTLt**, healthy liver within the perfused lobe) and **non-tumoral whole liver (NTLw**, whole healthy liver).

From the DVHs, we calculated D50 and D70 for tumoral and non-tumoral liver (minimum dose received by 50% and 70% of the ROI), V120 of tumoral and V20 of non-tumoral liver (percentage of volume receiving at least 120 and 20Gy, respectively).

Pearson's correlation coefficient (ρ) of these metrics between simulation (Tc-MAA) and therapy (Y-90) was analyzed.

Results

The mean tumour dose estimated from Tc-MAA was 174.0 ± 140.7 Gy whereas it was about 126.7 ± 88.2 Gy from ^{90}Y, showing a Pearson's correlation coefficient of 0.85 (*p-value < 0.001*) (Table 1 and Figure 2).

For NTLt, D50 and D70 show lower correlation (0.73 and 0.67, *p-value < 0.001*) than V20 (0.86, *p-value < 0.001*), whereas for NTLw each parameter presents similar values for D50, D70 and V20 (0.90, 0.85 and 0.88, respectively, *p-value < 0.001*).

Conclusions

Mean absorbed doses between Tc-MAA and ^{90}Y show high correlation for NTLt and NTLw. These results agree with other studies comparing dose profiles obtained from simulation and post-therapy imaging. D50 and D70 may be better estimators of tumoral liver dose distribution than V120. V20 may be better regarding non-tumoral liver target instead of D50 and D70, whereas similar coefficients were obtained for D50, D70 and V20 in NTLw.

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Table 1. Volume and dose-related parameters in simulation (Tc-MAA) and therapy (Y-90) for TL, NTLt and NTLw. The Pearson's correlation coefficient is shown as rho (ρ)

		MAD (Gy)			D_{50} (Gy)			D_{70} (Gy)			V_{20} / V_{120} (%)		
	Volume	Tc-MAA	Y-90	ρ	Tc-MAA	Y-90	ρ	Tc-MAA	Y-90	ρ	Tc-MAA	Y-90	ρ
TL	356.7 ± 384.2	174.0 ± 126.7	140.7 ± 88.2	0.85	148.9 ± 111.0	130.1 ± 85.9	0.83	115.2 ± 99.0	98.3 ± 68.5	0.86	0.5 ± 0.3	7.9 ± 0.3	0.79
NTLt	976.6 ± 462.0	69.7 ± 52.7	70.3 ± 38.3	0.90	46.2 ± 46.2	55.2 ± 32.2	0.73	32.2 ± 31.1	39.5 ± 24.9	0.67	0.6 ± 0.2	2.8 ± 0.3	0.86
NTLw	1566.3 ± 457.6	44.4 ± 25.5	48.9 ± 23.6	0.95	20.2 ± 19.7	33.9 ± 22.9	0.90	10.6 ± 11.4	19.9 ± 14.7	0.85	0.4 ± 0.2	1.0 ± 0.2	0.88