^{90}Yttrium PET/MR-Based Dosimetry After Liver Radioembolization (SIRT)

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Abstract: Biodistribution and dosimetric aspects are important issues in the preparation realization of radionuclide therapies and thus play an emerging role in radioembolization of liver malignancies. Biodistribution assessment of liver selective internal radiotherapy (SIRT) has been shown feasible using PET/CT PET/magnetic resonance (MR). Whereas prospective dosimetry using ^{99m}Tc-macroaggregated albumin SPECT/CT is discussed controversially, retrospective ^{90}Y PET/CT has been shown feasible for dosimetry of SIRT in recent studies. Considering the advantages of PET/MR with regard to lesion detection radiation dose reduction compared to PET/CT, especially when repeated scanning is intended, we investigated the use of PET/MR for dosimetry of liver SIRT.

Key Words: radioembolization, ^{90}Y, PET/MR, dosimetry

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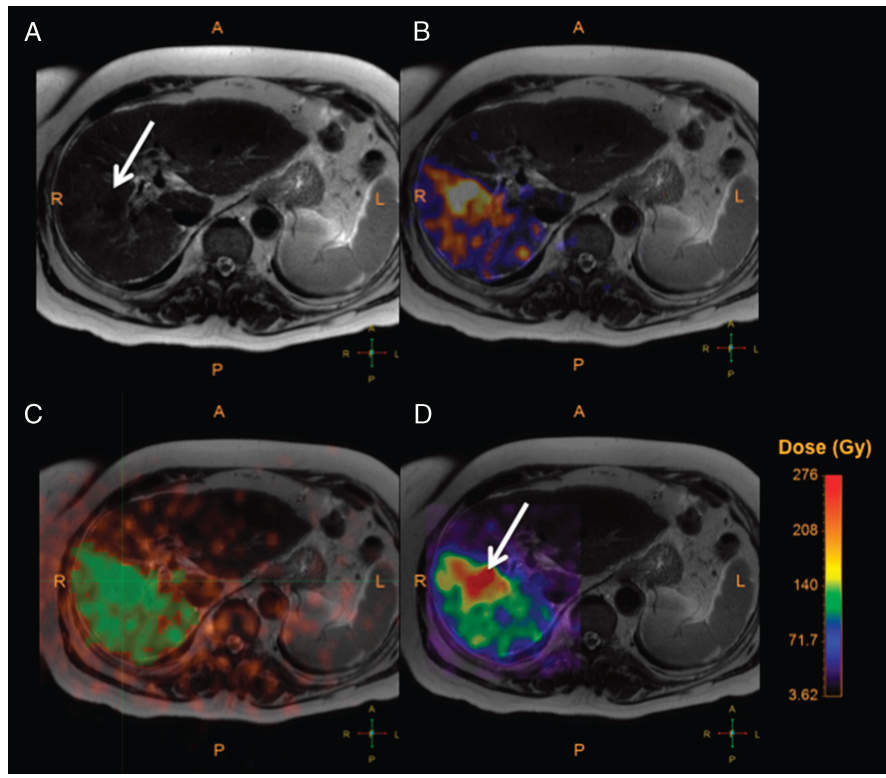

FIGURE 1. A 75-year-old woman with multifocal unresectable hepatocellular carcinoma (HCC) of the right lobe was referred for SIRT. The calculated activity of 1.9 GBq (51.4 mCi) of ^{90}Y- labeled Theraspheres (MDS Nordion, Kanata, Canada) were administered in a single bolus into the right liver lobe. Besides routinely performed Bremsstrahlung-SPECT/CT, biodistribution assessment of liver SIRT has been shown feasible using PET/CT[1,2] and PET/MR.[3] Considering the advantages of PET/MR with regard to lesion detection and radiation dose reduction compared to PET/CT, especially when repeated scanning for dosimetric purposes is intended, we investigated for the first time the use of PET/MR for single-time point posttreatment dosimetry of liver SIRT. This approach was also motivated by the fact that prospective dosimetry using ^{99m}Tc macroaggregated albumine SPECT/CT is still discussed controversially,[4,5] whereas posttreatment ^{90}Y PET/CT-based dosimetry has been shown feasible and reliable in recent studies.[6–8] Therefore, our patient underwent PET/MR on an integrated Philips Ingenuity TF PET/MR scanner 2 hours after the intra-arterial injection of the ^{90}Y-labeled microspheres. PET scanning (one bed position centered on the liver) lasted for 30 minutes. The MR protocol consisted of a 3-dimensional T1 gradient echo (FFE) sequence sequence (echo time, 2.3 milliseconds [ms]; repetition time [TR] 4.1 ms; voxel size, 3×3×6 mm) for attenuation correction, and axial as well as coronal T2 single-shot TSE sequences (echo time, 136 ms; repetition time, 2351 ms; voxel size, 1.2 × 1 × 5 mm [**A**]) for lesion depiction. The PET data were reconstructed using a 3-dimensional line-of-response–time of flight blob-based OSEM algorithm (3 iterations, 33 subsets) with a voxel size of 4 × 4 × 4 mm^3. PET/MR-based dosimetry was performed using the STRATOS software package on an Imalytics workstation (Philips Technologie GmbH Innovative Technologies, Aachen, Germany): after optimized image coregistration of MR (arrow in **A**: most important hepatocellular carcinoma lesion) and ^{90}Y time of flight PET (**B**), the segmentation of the right liver lobe (green area shown in **C**) was performed using a region growing algorithm with the hottest spot as seeding point and the count value of a nonlesional voxel as lower threshold. Subsequently, the voxelwise dose distribution was obtained using the ^{90}Y PET-specific kernel of the dose calculation algorithm. The color-scaled dose distribution centered on the voxel with the maximum lesion dose (arrow) is shown in **D**.

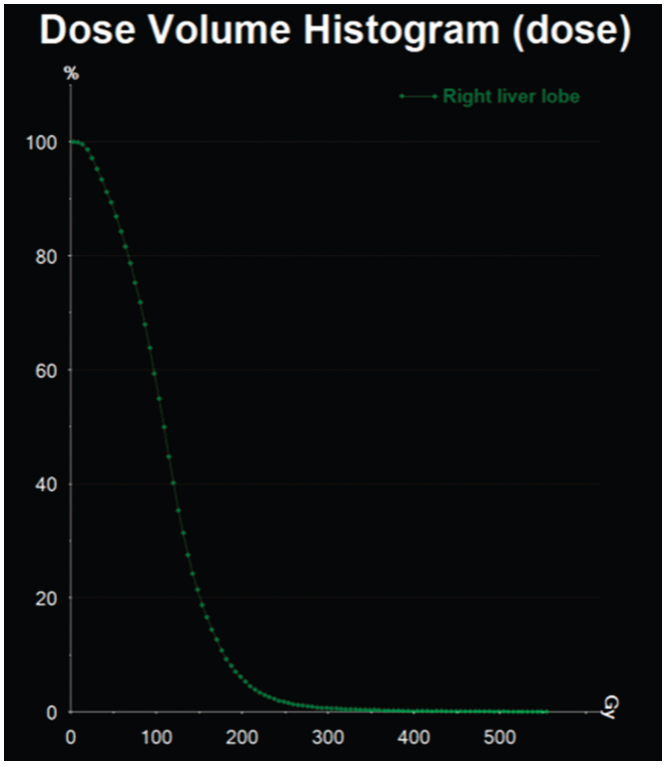

FIGURE 2. The dose-volume histogram is shown in Figure 2. Within the segmented volume of interest, the calculated maximum lesion dose of 276 Gy (Fig. 1D) is higher than data published by other authors who found maximum lesion doses up to 238 Gy in single time point estimations[8] The same is true for the healthy liver tissue, where we found doses of up to 45 Gy, whereas other authors[8] report up to 33.8 Gy. This difference might be at least partially attributed to the different geometry and properties of the glass spheres used in our institution compared to the ^{90}Y-labeled resins used in other publications. However, a cross-validation study with SPECT/CT and PET/CT is warranted and subject to ongoing research.