State-of-the-art yttrium-90 selective internal radiation therapy: Technical aspects of artery-specific SPECT/CT partition model dosimetry

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INTRODUCTION
Radiation therapy for solid tumors is always effective when delivered to the right dose (Gy). In the right location, to the right patient, with the right intent. Yttrium-90 (90Y) radioembolization failure is primarily due to one or a combination of these three factors. To date, radioactive internal dosimetry for 90Y radioembolization using 99mTc main microspheres (YSI Spheran) of Medical Limited) has yet to achieve new, re-engineering imaging modalities such as catheter-directed CT hepatic angiography (CATHA) and single-photon emission computed tomography with integrated low-dose CT (SPECT/CT).

OVERVIEW OF DOSIMETRIC TECHNIQUE
The artery-specific SPECT/CT partition model is a dosimetric technique developed by our institution which integrates catheter-directed CTHA, high-resolution microaggregated albumin (99mTc-MAA) SPECT/CT and partition modeling into a single unified state-of-the-art radioembolization technique (99mTc-MAA radioembolization).

Catheter-directed CTHA accurately delineates the margin of perfused hepatic arterial territories, superior to digital subtraction angiography. 99mTc-MAA SPECT/CT tomographically evaluates 99mTc-MAA hepatic biodistribution, superior to planar scintigraphy. Partition modeling is a validated and scientifically sound method of radioactive internal dosimetry for 99mTc main microspheres, superior to the body surface area method.

CLINICAL VALIDATION
From January to May 2012, 22 patients underwent 99mTc-MAA radioembolization using microspheres for inoperable hepatocellular carcinoma (HCC). Validation of the dosimetric technique was performed in 10 patients screened by catheter-specific-SPECT/CT partition modeling were available for analysis. All 22 patients had no significant toxicities within 24 hours post-radioembolization. Follow-up data was available in 5 patients at the time of this report. Median biochemical and imaging follow-up were at 6 months (range 4-11) and 8 months (range 6-11) respectively.

All 10 patients with the substantial reduction of lesions and new or variable lesions within planning target volumes. Serum alphafetoprotein was reduced by 87-95%. Clinical success was achieved in 80% (4 of 5 patients). Hepatic survival has not yet been achieved.

By partition modeling, a uniform tumor radiation dose of 80-90Gy to the target volume is not achieved but the target volume is reduced from non-tumorous cirrhosis. If non-tumorous liver be may occur liver biochemical decline on 11 months, some developed pulmonary toxicity up to 15Gy in large.

CONCLUSION
Early results show that artery-specific-SPECT/CT partition modeling for selective-90Y radioembolization in safe and effective for inoperable HCC. Advanced clinical applications include sub-lesional dosimetry, precision radiation segmentectomy/lobectomy and the treatment of hypervascular tumors.

STATE-OF-THE-ART 90Y RADIATION DOSE

90Y radioembolization shows a segment IV tumor supplied by the right and left hepatic arteries. 99mTc-MAA biodistribution and performs activity quantification. Visually guided by microangiography of the catheter-directed CTHA, 99mTc-MAA SPECT/CT regions of interest (ROI) are drawn for the planning target volume. Tumor and non-tumorous territories are segmented and radiation planning is based on the physician’s holistic assessment of patient-specific circumstances, in accordance to the current clinical outcome. 99mTc-MAA SPECT/CT regions of interest (ROI) are outlined for the right and left hepatic territories. The radiation therapy plan for each planning target volume is derived from the physician’s holistic assessment and radiation planning is based on the physician’s holistic assessment of patient-specific circumstances, in accordance to the current clinical outcome.

SINGLE ARTERIAL TERRITORY
Figure 1A: Selected arterial angiography with contrast of the proper hepatic artery. Figure 1B: Corresponding catheter-directed CTHA, showing the large enhancing hypervascular tumor and delineated arterial territory margin. Figure 2A: The radiation therapy plan for each planning target volume. Tc-MAA SPECT/CT with regions of interest (ROI). Regions of interest (ROI) are drawn for the planning target volume. The radiation therapy plan for each planning target volume is derived from the physician’s holistic assessment of patient-specific circumstances, in accordance to the current clinical outcome. 99mTc-MAA biodistribution and performs activity quantification.

THREE ARTERIAL TERRITORIES
Figure 3A: Selected arterial angiography with contrast of the proper hepatic artery. Figure 3B: Corresponding catheter-directed CTHA, showing the large enhancing hypervascular tumor and delineated arterial territory margin. Figure 4C: The radiation therapy plan for each planning target volume. Tc-MAA SPECT/CT with regions of interest (ROI). Regions of interest (ROI) are drawn for the planning target volume. The radiation therapy plan for each planning target volume is derived from the physician’s holistic assessment of patient-specific circumstances, in accordance to the current clinical outcome. 99mTc-MAA biodistribution and performs activity quantification.

SUB-LESIONAL DOSE
99mTc-MAA biodistribution and performs activity quantification. Visually guided by microangiography of the catheter-directed CTHA, 99mTc-MAA SPECT/CT regions of interest (ROI) are drawn for the planning target volume. Tc-MAA SPECT/CT with regions of interest (ROI). Regions of interest (ROI) are drawn for the planning target volume. The radiation therapy plan for each planning target volume is derived from the physician’s holistic assessment of patient-specific circumstances, in accordance to the current clinical outcome. 99mTc-MAA biodistribution and performs activity quantification.