Analysis of differences between ^{99m}Tc-MAA-SPECT and ^{90}Y-Microsphere-PET dosimetry

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MONTPELLIER CHU CENTRE HOSPITALIER UNIVERSITAIRE

DOSIsoft

SNMMI SOCIETY OF NUCLEAR MEDICINE AND MOLECULAR IMAGING

ANNUAL MEETING

June 23 - 26, 2018 > Philadelphia, PA

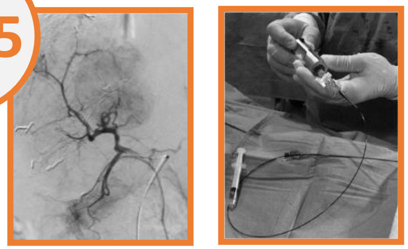
PhD in collaboration between:

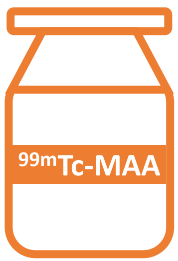
DOSIsoft & CHU Montpellier (Centre Hospitalier Universitaire)

Introduction

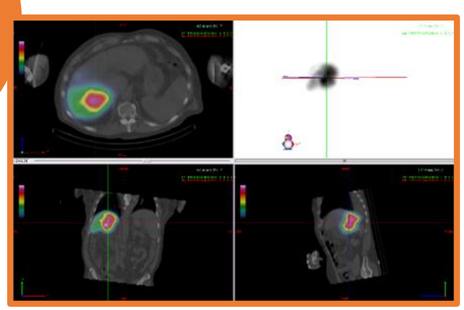
1. Simulation

D-15





SPECT/CT



Predictive Dosimetry

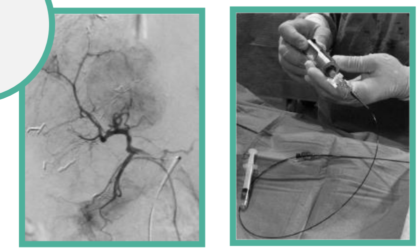
Procedure implies:
- Reproducibility
- Vascularization

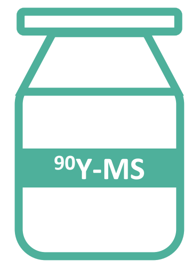
Different particles:
- Size
- Density
- Number of particles

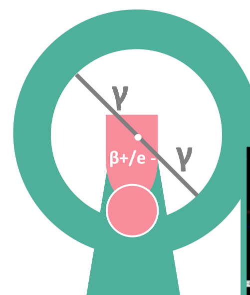
Different imaging modality:
- Isotope
- S/B Ratio

2. Treatment

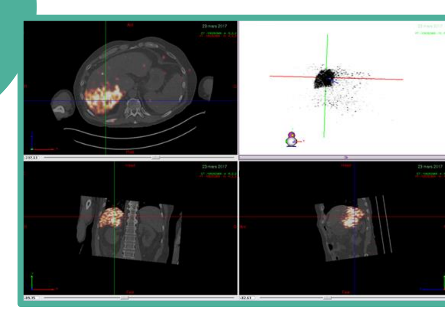
D







PET/CT



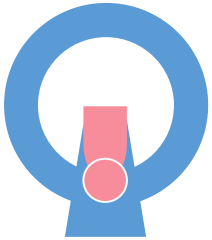
Post-treatment Dosimetry

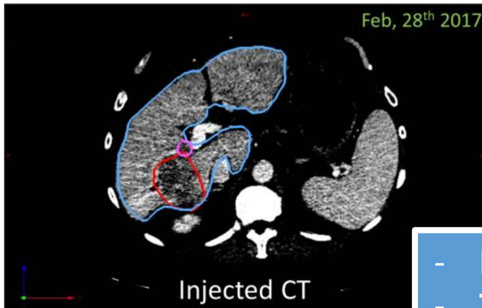
Materials & Methods

Population

- **20 patients**
- **21 treatments**
- **Between 2015 and 2018**
- **HCC (intermediate or advanced)**
- **Glass microspheres (TheraSphere®, BTG)**
- **Time between MAA and microsphere injection: 18 ± 7 days**
- **Administered activity: 3.7 ± 1.2 GBq**
- **Lung shunt: 2.4 ± 4.3 %**
- **Tumor volume: 514 ± 407 mL**

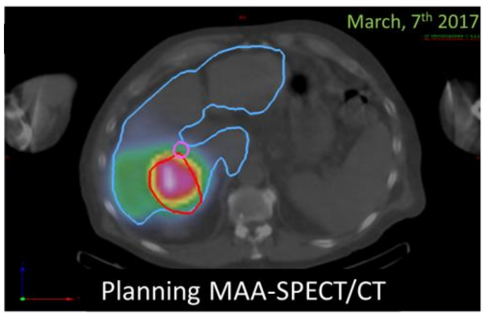
1. Segmentation

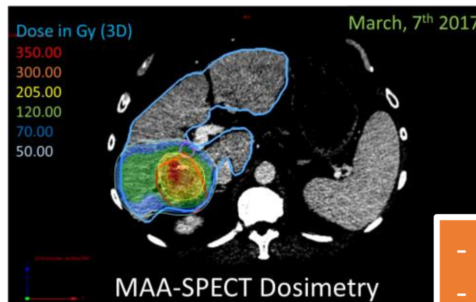




- Radiology team
- Total liver + Lesion(s) > 2cm
- AW Workstation (GE Healthcare, Waukesha, WI, USA)

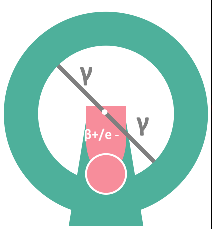
2. Predictive Dosimetry

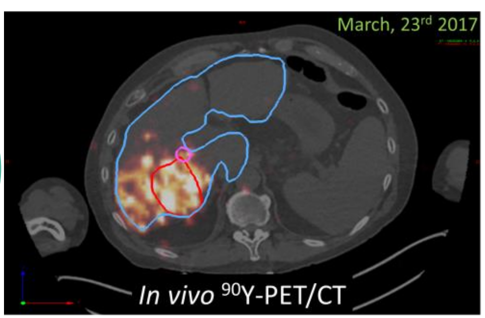


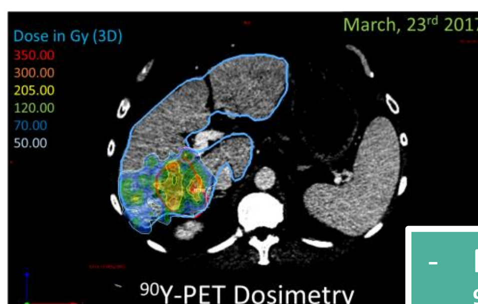


- Multi-modal registration
- ^{99m}Tc-MAA SPECT based dosimetry
- PLANET® Dose (DOSIsoft, Cachan, France)

3. Post-treatment Dosimetry







- Multi-modal registration
- ^{90}Y-Microsphere PET based dosimetry
- PLANET® Dose (DOSIsoft, Cachan, France)

Gear *et al. EJNMMI Physics* (2016) 3:17
DOI 10.1186/s40658-016-0151-6

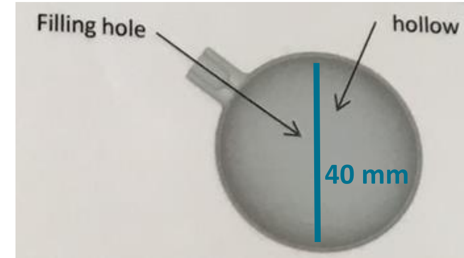
EJNMMI Physics

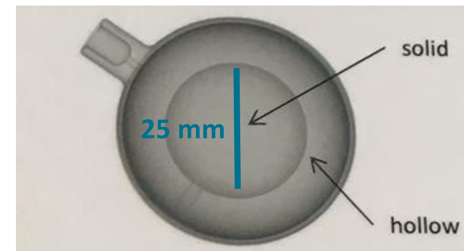
ORIGINAL RESEARCH **Open Access**

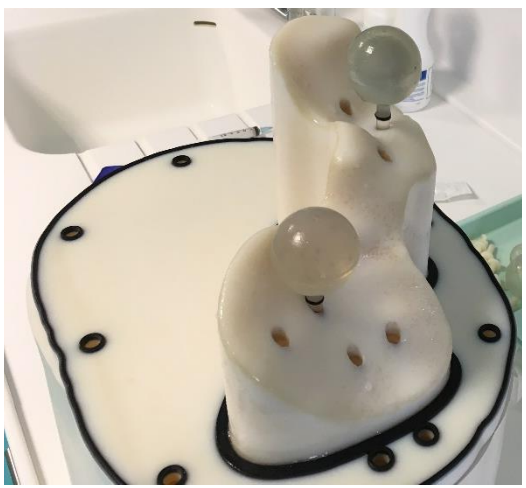
Abdo-Man: a 3D-printed anthropomorphic phantom for validating quantitative SIRT

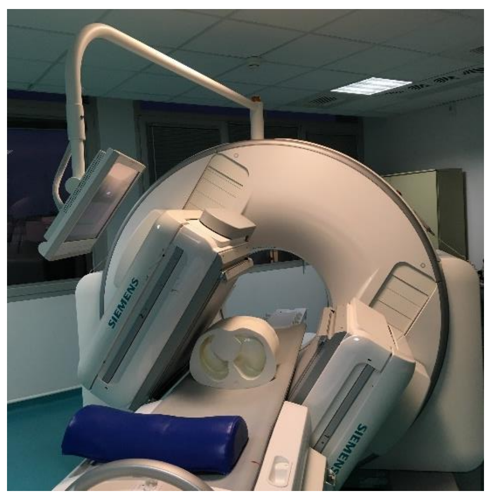
Jonathan I. Gear[1*], Craig Cummings[1], Allison J. Craig[1], Antigoni Divoli[1], Clive D. C. Long[1], Michael Tapner[2] and Glenn D. Flux[1]

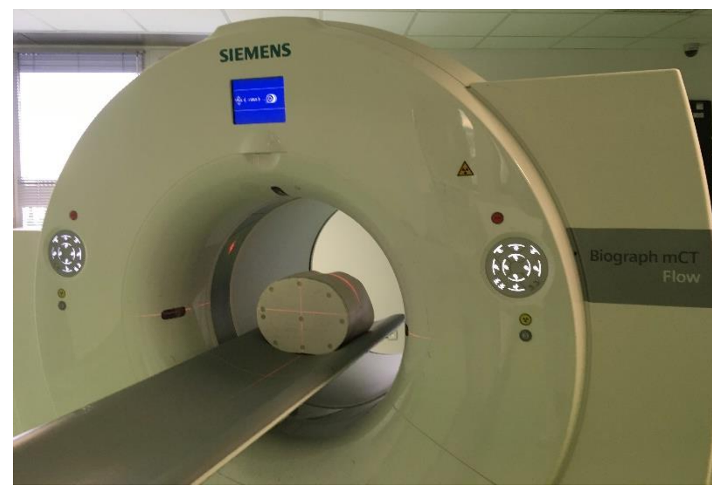
- ^{99m}Tc Activity: 315 MBq
- ^{90}Y Activity: 2.6 GBq
- Tumor/Normal Liver 5:1











Predictive vs. Post-treatment Dosimetry

→Planned vs. delivered activity

→Interventional Radiology

→Phantom

→Imaging

Results

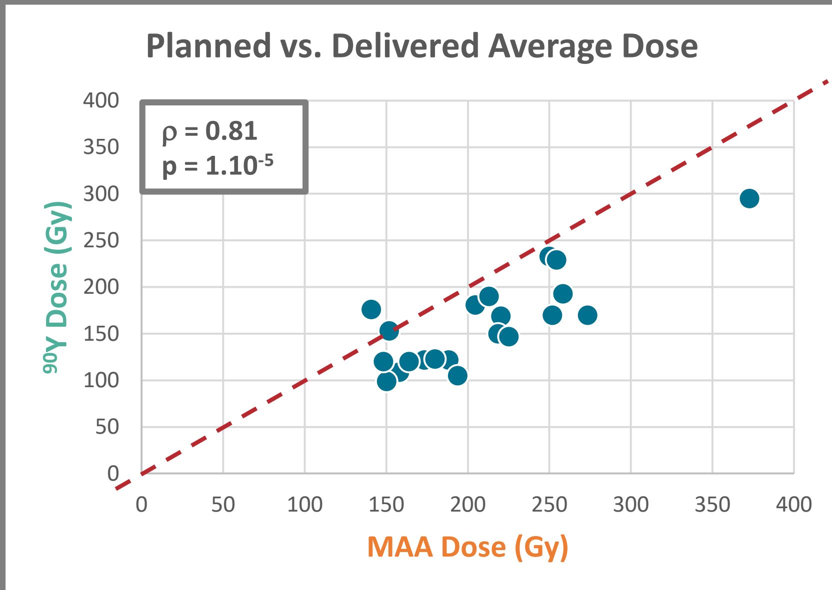
Dose Results

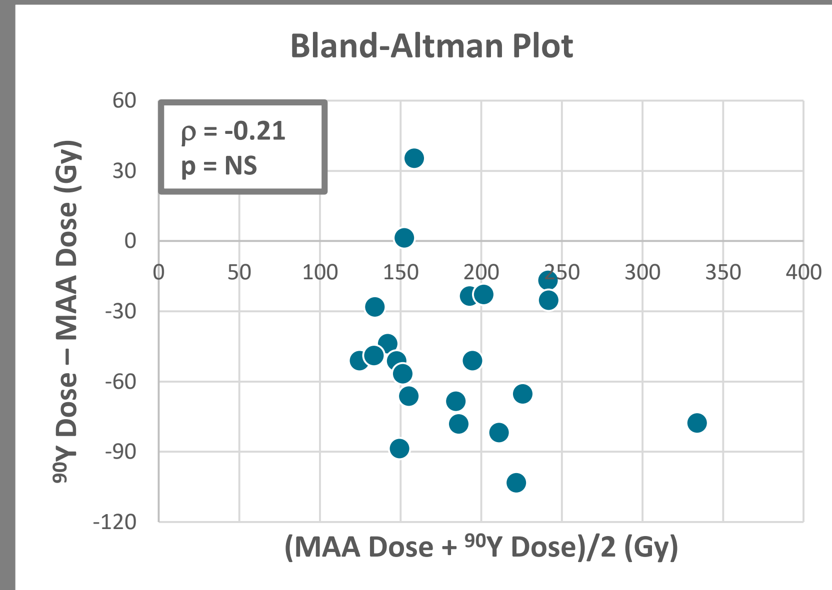
	^{99m}Tc-MAA			^{90}Y-Microsphere			Student's Test (p)	Pearson's Correlation
	Mean	SD	Range	Mean	SD	Range		
D_{avg} Tumor (Gy)	**209**	56	141-373	**161**	49	99-295	1.10^{-6}	0.81 ($p = 1.10^{-5}$)
D_{avg} Normal Liver (Gy)	**45**	16	11-75	**35**	14	16-63	9.10^{-6}	0.88 ($p = 1.10^{-7}$)

	MAA vs. ^{90}Y Mean Deviation
D_{avg} Tumor	**25 ± 12 %**
D_{avg} Normal Liver	**27 ± 12 %**

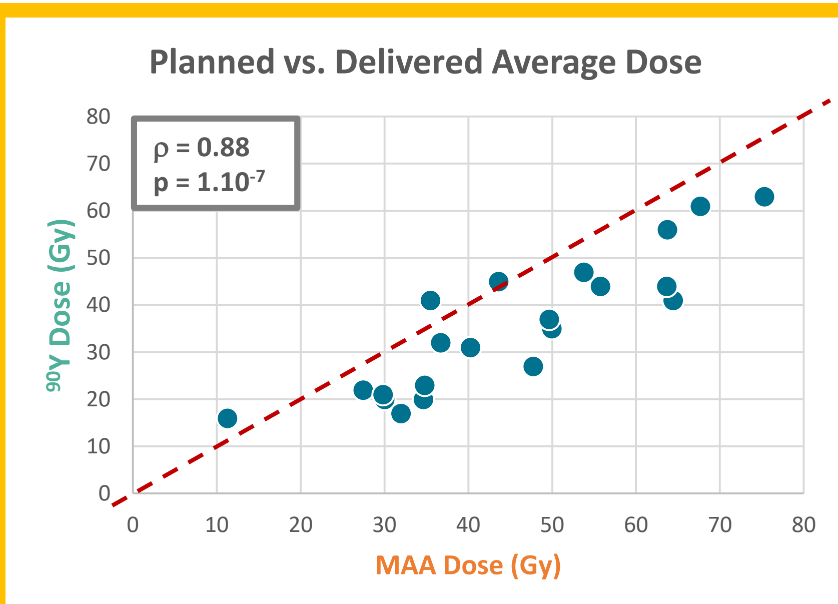
Correlation

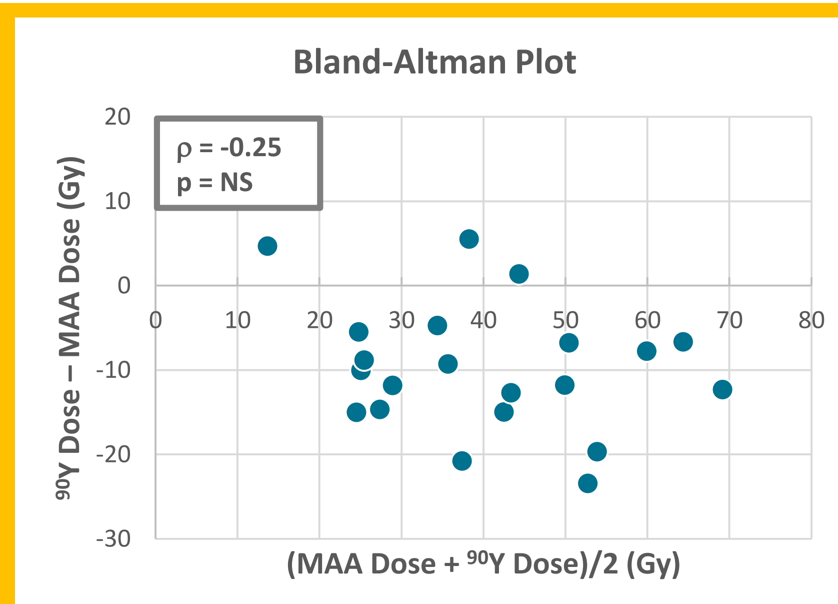
Tumor





Normal Liver



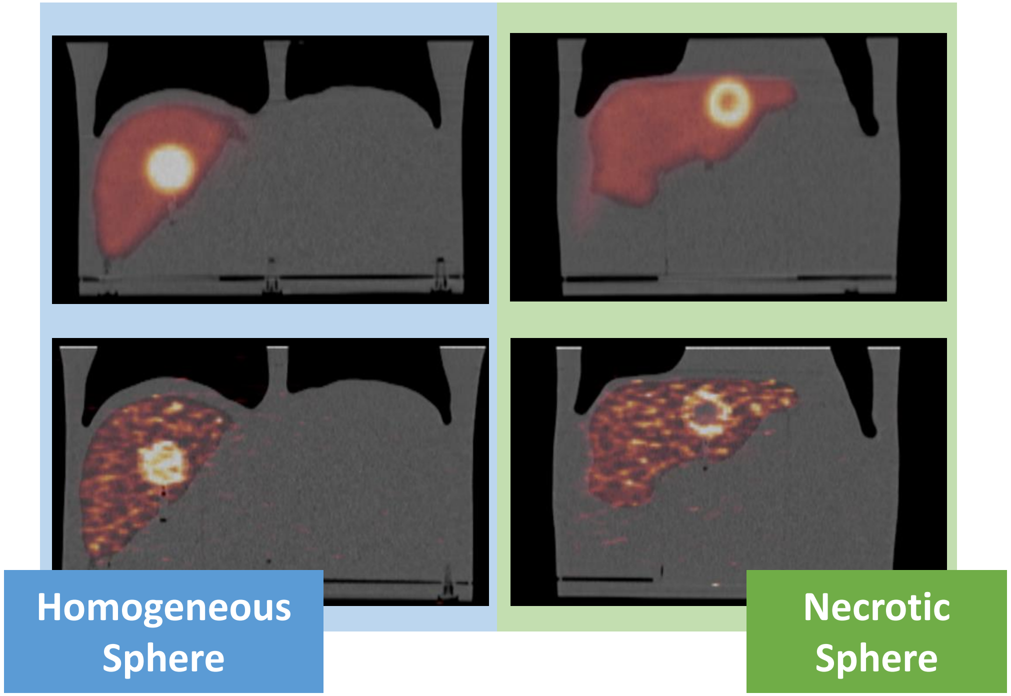


Wished vs. Delivered Activity: 7 ± 8 %

- Vial Selection
- Vial Calibration
- Injection Time
- Residual Activity

Radiological Gesture:

- Same Operator: 9/21
- Same Material used: 14/20 (1 NA)
- Same Position: 16/20 (1 NA), 4 slightly different positions
- Volume of Injection: 5 mL of MAA vs. 60 mL of microspheres (including rinsing)



	D_{avg} ^{99m}Tc	D_{avg} ^{90}Y	Deviation
Homogeneous Sphere	236 Gy	225 Gy	-5%
Necrotic Sphere	178 Gy	211 Gy	19%
Normal Liver	60 Gy	59 Gy	-2%

- Low branching ratio (31.86 x 10^{-6})
- Large random fraction (Bremsstrahlung + ^{176}Lu)
- Scatter correction
- Misplaced counts (Willowson et al.)
- Larges spheres, recovery of 80% (Carlier et al.)

Medical Physics
The International Journal of Medical Physics Research and Practice

90Y -PET imaging: Exploring limitations and accuracy under conditions of low counts and high random fraction

Thomas Carlier, Kathy P. Willowson, Eugene Fourkal, Dale L. Bailey, Mohan Doss, and Maurizio Conti

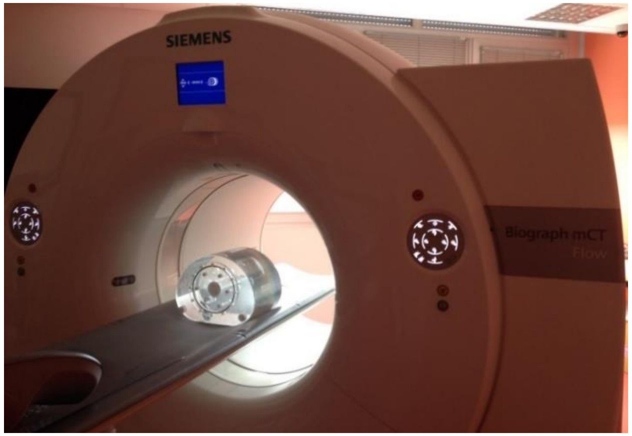
Citation: Medical Physics 42, 4295 (2015); doi: 10.1118/1.4922685

Medical Physics
The International Journal of Medical Physics Research and Practice

Quantitative 90Y image reconstruction in PET

Kathy Willowson, Nicholas Forwood, Bjoern W. Jakoby, Anne M. Smith, and Dale L. Bailey

Citation: Medical Physics **39**, 7153 (2012); doi: 10.1118/1.4762403



NEMA/IEC 2001 ^{90}Y solution

$$\frac{Injected\ Activity}{Activity\ in\ the\ Field\ of\ View} = 1.03$$

Planned MAA-based dosimetry vs. ^{90}Y post-treatment dosimetry:

	^{99m}Tc-MAA			^{90}Y-Microsphere			Student's Test (p)	Pearson's Correlation
	Mean	SD	Range	Mean	SD	Range		
D_{avg} Tumor (Gy)	**209**	56	141-373	**161**	49	99-295	1.10^{-6}	0.81 ($p = 1.10^{-5}$)
D_{avg} Normal Liver (Gy)	**45**	16	11-75	**35**	14	16-63	9.10^{-6}	0.88 ($p = 1.10^{-7}$)

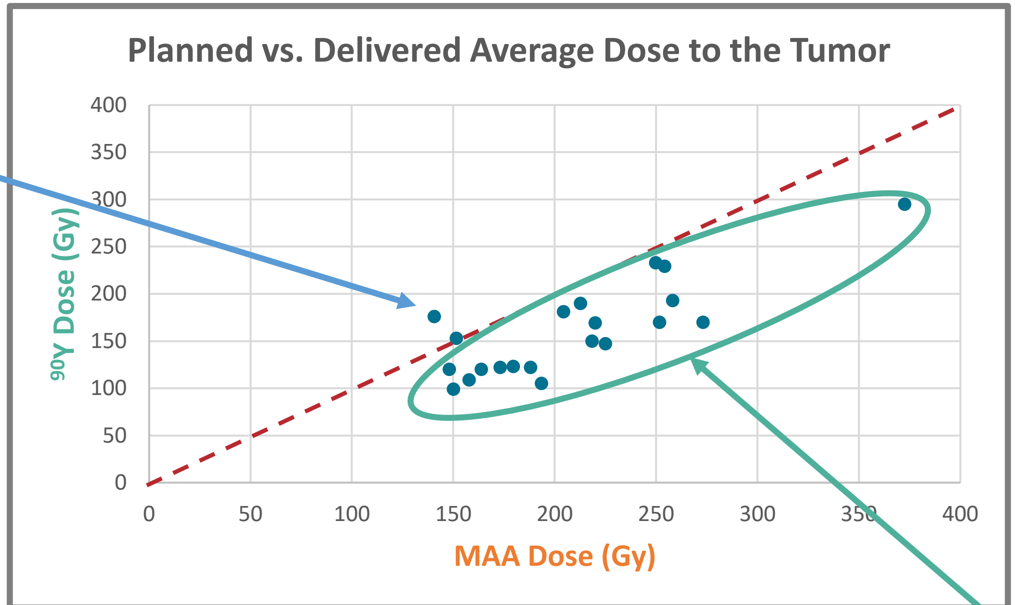
Renormalized MAA-based dosimetry vs. ^{90}Y post-treatment dosimetry:

	^{99m}Tc-MAA			^{90}Y-Microsphere			Student's Test (p)	Pearson's Correlation
	Mean	SD	Range	Mean	SD	Range		
D_{avg} Tumor (Gy)	**164**	40	115-281	**161**	49	99-295	NS	0.88 ($p = 2.10^{-7}$)
D_{avg} Normal Liver (Gy)	**36**	15	8-69	**35**	14	16-63	NS	0.92 ($p = 3.10^{-9}$)

→ Dose deviations mainly related to imaging modality differences

Discussion/Conclusion

Discussion/Conclusion



Better tumor targetting during treatment

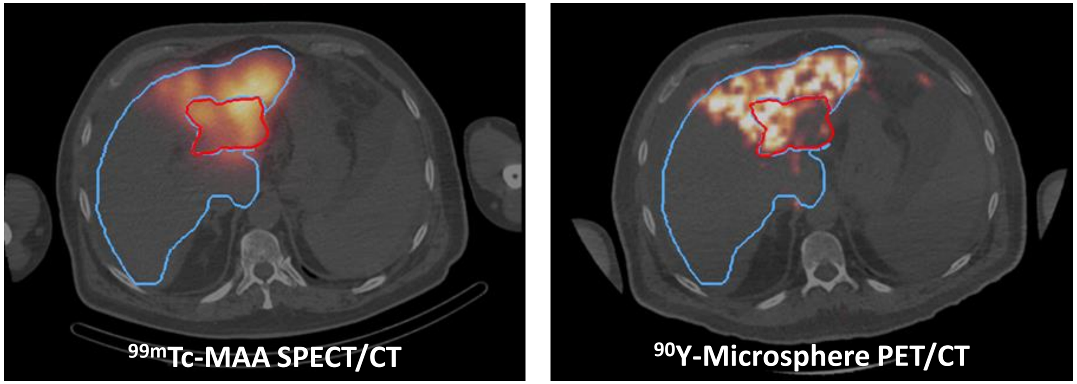
- **Residual Activity**
- **Injection Time**
- **^{90}Y-PET Quantification**

Although planned vs. delivered dosimetry are significantly different, they are correlated → ^{99m}Tc-MAA-based dosimetry is today the best option for dosimetry planning

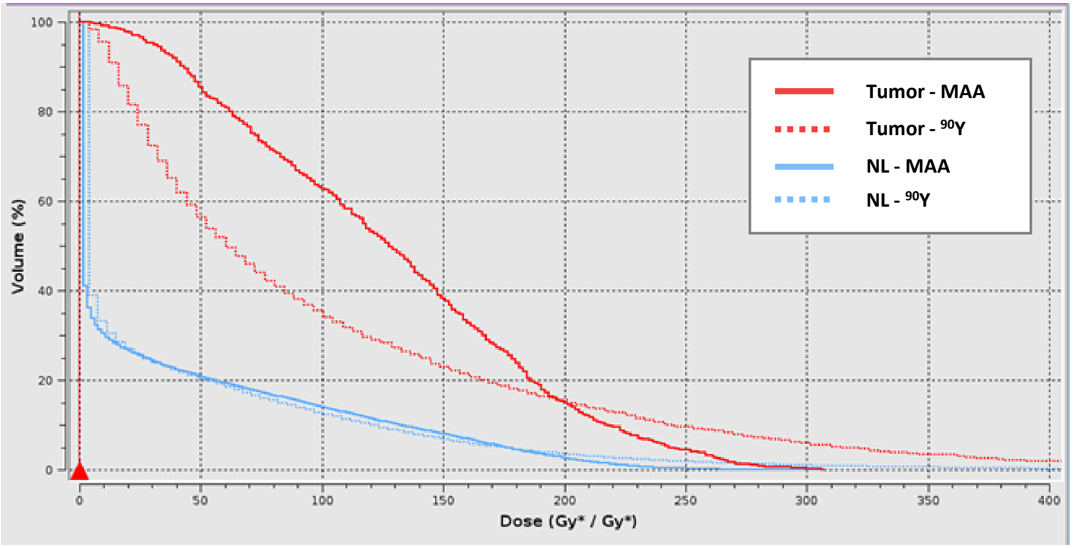

Thank you

	^{99m}Tc-MAA	^{90}Y-Microspheres
D_{avg}	128 Gy	99 Gy
D_{70}	83 Gy	31 Gy
D_{50}	127 Gy	59 Gy
$D_{avg\text{-}NL}$	31 Gy	32 Gy

V_{Tumor} = 119 mL



Different Operator and Catheter



→ Different MAA and microsphere distributions

SPECT

Symbia Intevo (Siemens)
Window: 140 keV ± 7.5%
32 projections
25s/projection
Matrix: 128 x 128
Voxel size: 4.79 x 4.79 x 4.79 mm^3
Low Energy Collimator
Flash 3D Iterative Reconstruction
5 iterations/8 subsets
Attenuation and Scatter corrections
Acquisition Time: 16 min

PET

Biograph mCT (Siemens)
1 bed (20 min)
Matrix: 200 x 200
Voxel size: 2.04 x 2.04 x 2.04 mm^3
PSF (TrueX) + TOF
2 iterations/21 subsets
All-Pass Filter
Attenuation and Scatter corrections
Acquisition Time: 20 min