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TARE Clinical Workflow

Planning

~2 weeks

Major impediments: Dose prediction and dose verification

Patient referred for TARE



Y-90 activity calculation



BSA model (resin spheres)

Repeat angiogram





Hepatic angiogram



^{99m}Tc-MAA SPECT



Treatment How did we do? Anterior Posterior

Better with PET?

Gamma or SPECT



Dose Calculation: Challenges

- MIRD •
- Voxel S-value
- Dose kernel •
- Full Monte Carlo







Computational burden

Computational Fluid Dynamics Simulation for 3D Dosimetry



Personalized treatment planning

Segmentation of Patient Hepatic Arterial Tree from Cone Beam CT

CBCT acquired on breath hold during planning





CBCT volume (0.25 mm pixel size, 1 mm slices)



Amirtaha Taebi

Preliminary CFD Simulation





Blood fluid properties Boundary conditions



Amirtaha Taebi

A Multimodal Imaging Approach





Putting it together for flow simulation...

Flow Simulation: Multiscale Modeling



UCDAVIS

 Segmented arterial tree combined with 3-element Windkessel model (RCR) for arterioles

 RCR circuit components are tuned using a whole-body 0D model

> Taebi, Vu, Roncali, "Multi-scale computational fluid dynamics modeling for personalized liver cancer radioembolization dosimetry"

Blood Flow and Microsphere Distribution



UCDAVIS

- Lobar injection:
 segments received 5%-40%
- Selective injection: tumor received 82%

→ Tumor received 61% of microspheres after both injections

Taebi, Vu, Roncali

3D Microsphere Distribution



Dose Kernel Calculation



Dose point kernel (DPK): Efficient, accurate solution for uniform tissues Monte Carlo: Toward accurate patient-specific absorbed dose... ...But computationally intensive Emilie Roncali, Gate Technical Workshop, July 4th 2019



Gy

Absorbed Dose distribution

Patient specific

Y-90 Dose Kernel: Energy Spectrum

 Use Fermi theory for beta decay to calculate energy distribution N(E):

$$N(E) = C\sqrt{E^2 + 2m_ec^2 \cdot E} \cdot (Q - E)^2 \cdot (E + m_ec^2) \cdot F(Z, E) \cdot S(E)$$

- Max energy Q = 2.28 MeV
- Mean energy = 936 keV





Y-90 Dose Kernel: Use GATE Dose Actor



Sphere, voxel number and total space calculated to match that of desired voxel size

⁹⁰Y: beta isotropic point source defined by • Collect ~5 10⁵ -10⁶ events in 280 x 280 x 280

3D Dose distribution

Kernel profile (3.64 mm)



Dose distribution (projection)



¹⁷⁷Lu Dosimetry work at UCSF



Sara St James

We have open post-doctoral positions! Contact sara.st.james@ucsf.edu

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