

uptake distribution is flat across much of the sphere, with only a thin skin. This flat uptake behavior does not change with motion up to amplitudes of 10 mm. We have also developed a matrix of correction factors to the flat behavior for motion amplitudes and tumor volumes beyond these limits.

Conclusion: Our data demonstrate for the first time, that true heterogeneity of NSCLC tumors can be modeled by SUV uptake which takes a Gaussian, Woods-Saxon or double-peaked functional form depending on tumor volume. The model we developed defines the “true” SUV distribution within tumor free of artifacts due to motion, and tumor volume and will therefore allow PET and potentially other metabolic studies to be optimally integrated into treatment plans.

Author Disclosure: K. Wijesooriya: None. P. Peng: None. P.W. Read: None. T. Pan: None. A. Goode: None. P. Judy: None. S. Benedict: None. J.M. Larner: None.

3728

Customized Vaginal Vault Brachytherapy With CT Imaging-derived Applicator Prototyping

E.M. Wiebe, G. Thomas, L. Barbera, H. Easton, and A. Ravi; *Odette Cancer Centre, Toronto, ON, Canada*

Purpose/Objective(s): Intracavitary vaginal brachytherapy is typically delivered with a standard applicator of uniform diameter. The clinical use of a stereolithographic mold technique to produce customized mold shapes, and allow for optimized brachytherapy dose distribution, is explored.

Materials/Methods: Stereolithographic technique is possible for cases such as a patient with surgical pathology diagnosis of early endometrial cancer with risk factors for local recurrence was identified clinically to have an irregular vaginal vault configuration with deep ‘dog-ear’ configuration and a wide vaginal apex (4.0 cm) relative to the 2.5 cm vaginal introitus. CT simulation images were obtained with contrast-soaked vaginal packing in situ to highlight unique anatomical detail. The area with packing was contoured and converted into a 3-dimensional digital image. The resulting 3-dimensional model was subsequently converted into a custom applicator with the use of high-resolution rapid prototyping.

Results: A custom vaginal applicator was formed with technical and practical design considerations for permitting greater lateral dose dispersion at vaginal apex compared to the standard uniform cylinder, facilitating clinical use, and limiting doses to organs at risk. These goals were achieved using a 2-part construction, optimized channel placement, and utilization of an alignment dowel. Stereolithographic production was available within a clinically acceptable timeframe.

Dosimetric results with the custom applicator were compared to calculated dosimetry for the standard cylinder best suited for the patient’s anatomy (2.5 cm in diameter). Inverse planning with a prescription point at 5 mm depth resulted in improved dose distribution towards the lateral aspect of vaginal vault of the custom cylinder relative to the standard cylinder; 700 cGy versus 328 cGy, respectively. The multi-catheter design allows for effective treatment of the wide vaginal apex, while simultaneously achieving relatively narrow dose distribution in the anterior/posterior direction, directly translating to rectal and bladder sparing compared to standard cylinder shapes.

Conclusions: Stereolithographic techniques with high resolution rapid prototyping are clinically feasible for the provision of patient-specific intracavitary applicators, and allow for significant improvement in dosimetric outcomes of vaginal tissue coverage compared to standard cylinder applicators.

Author Disclosure: E.M. Wiebe: None. G. Thomas: None. L. Barbera: None. H. Easton: None. A. Ravi: None.

3729

Improving Clinical Target Volume (CTV) Dose Homogeneity and Normal Tissue Maximum Dose for Endoesophageal High-dose-rate (HDR) Brachytherapy: One Versus 3 HDR Tube Technique

J.F. Greskovich, M.D. Kolar, A. Wilkinson, and A. Godley; *Cleveland Clinic, Cleveland, OH*

Purpose/Objective(s): We conducted a dose-volume comparison for CTV and normal tissues after placement of one or three HDR brachytherapy tubes in eleven patients undergoing esophageal HDR brachytherapy.

Materials/Methods: A patient with squamous cell carcinoma in situ with foci suspicious for superficial invasion was treated definitively with HDR brachytherapy, 30Gy in 6 applications, delivered once per week. The first fraction used a single 1.5 meter brachytherapy tube; subsequent fractions used 3 tubes. Radiopaque clips were placed 2 cm proximal and 2 cm distal to endoscopic tumor. The patient underwent CT-based treatment planning. The CTV was defined as a 2 mm thickness of the mucosal wall between the distal and proximal radiopaque clips. We evaluated the dose-volume relationships for CTV and normal tissues for the one versus three catheter techniques, each planned with V100 of 90%. The maximum dose to the normal tissues was defined as the dose received by a volume of 0.04 cc. Dice’s Coefficient (DC) was calculated in eleven additional patients who underwent 43 total HDR applications (36 three-tube technique, 7 one-tube). DC is calculated as overlap volume of the prescription isodose line (PIDL) with the CTV (i.e., CTV V100) divided by average volume of PIDL and CTV, with DC = 1 representing perfect agreement. The advantage of DC over conformity index is that it includes under- as well as over-lap information.

Results: The V100, V150, V200, V300 were 90.0%, 73.5%, 62.3%, 46.0% vs. 90.2%, 66.7%, 41.5%, 17.7%, for the one and three catheter placements, respectively. For the three catheter technique, the implant volume was 50% smaller (V100: 42.7cc vs. 83.8cc; V150: 22.2cc vs. 42.9cc; V200: 13.1cc vs. 26.0cc; V300: 5.6cc vs. 12.3cc). With respect to the normal tissues, the heart (6.0Gy vs. 11.2Gy), right lung (4.3Gy vs. 12.0Gy), right proximal bronchial tree (6.2Gy vs. 13.1Gy), trachea (5.8Gy vs. 7.3Gy), and vertebral body (6.5Gy vs. 13.1Gy) received much lower doses per fraction using the three catheter technique vs. the single catheter technique. Comparing 11 patients, using 3 catheters, the DC significantly improves to 0.38 from 0.30 vs. 1 catheter, P<0.058. In this case, comparing a tubular CTV, to a cylindrical PIDL, the best DC achievable is 0.56 on average.

Conclusions: The dose homogeneity and DC was improved using 3 brachytherapy catheters vs. 1 catheter. The 3 catheter technique led to 50% smaller implant volumes receiving high fractional dose, lower maximum normal tissue doses, and more conformal dose. This improvement in decreasing the volume of the “hot spots” both to the CTV and normal tissues may lead to an improved therapeutic ratio with lower rates of complications.

Author Disclosure: J.F. Greskovich: None. M.D. Kolar: None. A. Wilkinson: None. A. Godley: None.

3730

Optimization of Monte Carlo Code for Clinical Simulation of Electron Beams

P. Guerra Gutierrez,¹ J.M. Udias,² E. Herranz,² M. Valdivieso,³ J. Calama,⁴ C. Illana,³ M.J. Ledesma-Carbayo,^{1,5} and A. Santos^{1,5}; ¹Universidad Politécnica de Madrid, Madrid, Spain, ²Universidad Complutense de Madrid, Madrid, Spain, ³GMV, Madrid, Spain, ⁴Clinica La Luz, Madrid, Spain, ⁵CIBER-BBN, Madrid, Spain

Purpose/Objective(s): The aim of this work is to optimize a Monte Carlo (MC) kernel for electron radiation therapy (IOERT) compatible with intraoperative usage and to integrate it within an existing IOERT dedicated treatment planning system (TPS).

Materials/Methods: The MC method is known to accurately calculate dose distributions but computational may limit their clinical use. In this work the existing Dose Planning Method is recoded in C++ and optimized for parallel execution in Windows based multi-core platforms, with no change in the physics modeling. Parallelization at the particle level with Windows native threads is straightforward. Read only data structures are shared among threads, to reduce memory footprint and increase cache hits, while dose volumes are per thread to avoid access contention. Particles are created on-line, based on tabulated phase spaces. These have been computed for energies between 6 and 20 MeVs and applicator diameters between 5 and 9 cm using a maximum likelihood iterative algorithm that

estimates particle distributions, based on water measurements. The actual clinical setup for IOERT is considered to evaluate the kernel. Phase space characterization and dose distributions correspond with experimental measurements from a commercial linear accelerator.

Results: Execution time to meet a target uncertainty grows with energy and applicator section. Performance improvements of MC codes by threading into multiple cores strongly depend on the memory architecture. Simulations for 1x1x1 mm³ water phantoms were run in an Intel i7-870 with every combination of applicator diameter and energy, with an excellent agreement in the mean energy and build up regions. Computation time for a 4% uncertainty ranges from 1' (5 cm/6MeVs) to 12' (9 cm/20MeVs). Dose computation in the breast, where radiation penetration is limited by protection, is executed in around a minute.

Conclusions: The implemented code allows for clinically relevant dose computations within a reasonable time. The tool narrows the gap between external and intraoperative radiation therapy, enabling radiation oncologists to plan treatment for the possible scenarios he may face.

Acknowledgment: This work is supported by projects CENIT-AMIT, IPT-300000-2010-3, TEC2010-21619-C04-3 and P2009/DPI-1802.

Author Disclosure: P. Guerra Gutierrez: None. J.M. Udias: None. E. Herranz: None. M. Valdivieso: None. J. Calama: None. C. Illana: None. M.J. Ledesma-Carbayo: None. A. Santos: None.

3731

Study of the Radiation Dose Enhancement at the Gold-Tissue Interface in Gold Nanoparticle-aided Radiation Therapy With Microdosimetry Technique

E. Parsai, N. Paudel, and D. Shvydka; *University of Toledo Health Science Campus, Toledo, OH*

Purpose/Objective(s): Nanoparticles of high atomic number materials, such as gold nanoparticles (AuNP), have shown a lot of promise in their exploitation for local tumor dose enhancement in radiation therapy, especially in the low energy range relevant to brachytherapy applications. Most researchers study the dose enhancement effect through either Monte Carlo (MC) simulations, or experimental approaches involving biological systems, where achievable physical dose enhancements are difficult to quantify. The dosimetry in such a system is not trivial, as the dose enhancement rapidly falls-off over a very short distance from the gold-tissue interface. The purpose of this study is to establish a micro-dosimetry technique for the experimental verification of dose enhancement in the neighborhood of gold-tissue interface.

Materials/Methods: The spatial distribution of the dose enhancement near the gold-tissue interface is modeled with Monte Carlo (MC) package MCNP5 in a 1-dimensional approach. Thin gold foil was placed in a tissue phantom comprising of ICRU-4 components. The model replicates the experiment, where the dose enhancement due to gold foils having thicknesses of 1, 10, and 100µm and areas of 12.5x25mm² are placed at a short distance from clinical HDR brachytherapy (Ir-192) source. The measurements are carried out with a thin-film CdTe-based photodetector, having thickness < 10µm, and operating in a photovoltaic mode. The small thickness of the detector ensures high spatial resolution of the measurement at progressively increasing distances from the foil.

Results: Our MC simulation results indicate that for Ir-192 energy spectrum the dose enhancement region extends over the distance of ~1 mm from the foil, where the magnitude of enhancement changes from several hundred to just a few percent. Our experimental results for gold foils of several thicknesses are in close agreement with the modeled data, confirming the feasibility of the explored micro-dosimetry approach. We also investigated an influence of the photodetector substrate on the measured data.

Conclusion: We have successfully established a micro-dosimetry technique for experimental verification of the dose enhancement near gold-tissue interface, applicable to the AuNP-aided radiation therapy treatments. Our approach will pave a way for direct assessment of the dose in experiments on biological models, shedding some light on apparent discrepancy between the physical dose enhancement and resulting biological effect.

Author Disclosure: E. Parsai: None. N. Paudel: None. D. Shvydka: None.

3732

Validation of High-Resolution Multimodality Imaging of Pretreatment Lung Function in Pulmonary Neoplasms

T. Diwanji,¹ S. Pokharel,² S. Feigenberg,¹ W. D'Souza,¹ and N. Mistry¹;
¹University of Maryland School of Medicine, Baltimore, MD, ²Morgan State University, Baltimore, MD

Purpose/Objective(s): There is a growing interest in using functional information for treatment planning. However, existing clinical techniques are limited in value due to their low spatial resolution. Here, we propose the use of multi-modality imaging of lung ventilation and lung perfusion at high spatial resolution using 4D-CT and 4D-Dynamic Contrast Enhanced MRI (DCE-MRI), respectively. Furthermore, we validate these techniques against the current clinical standards for evaluation of lung function, i.e., Scintigraphy Ventilation and Perfusion (VQ scans) and Pulmonary Function Tests (PFTs).

Materials/Methods: VQ scans, 4D-CT, and DCE-MRIs, were acquired in 4 patients prior to radiation therapy. PFTs were acquired in 3 out of the 4 patients. 4D-CT images were used to create 3D fractional regional ventilation (FRV) maps by applying a "mass correction" and subtracting the spatially matched end-exhale and end-inhale images. DCE-MRI images were acquired using a fast-volumetric scan that tracks a bolus of a gadolinium based contrast agent to extract voxel-by-voxel estimates pulmonary blood flow (PBF). Standard clinical protocols were utilized for the acquisition and analysis of scintigraphy VQ data. Manual contouring of the lung was performed to eliminate the heart and large blood vessels from the analysis. FRV and PBF maps were collapsed in the anterior-posterior dimension to create coronal 2D projection images consistent with the scintigraphy VQ scan images. The projections were divided into 6 sections of equal height analogous to the analysis performed on VQ scans and statistically compared using the Kendall's tau rank correlation.

Results: Kendall's tau estimate for correlation between the FRV/PBF and V/Q measurements are reported in Table. Mean functional residual capacities (FRC) from the PFTs (N = 3) versus calculated FRCs from FRV maps were 2.7 +/- 0.6 L and 2.4 +/- 0.7 L, respectively, and the null hypothesis could not be rejected (p = 0.61), implying statistical similarity between multi-modality techniques and "gold-standard".

Conclusion: There was a strong correlation between scintigraphy VQ and multimodality measurements of ventilation and perfusion. The similarity between the calculated and measured FRCs further validates the utility of 4D-CT to evaluate ventilation. Furthermore, the significant increase in spatial resolution compared to the clinical "gold-standard" highlights the utility of high-resolution multi-modality functional lung imaging.

Poster Viewing Abstract 3732; Table Correlation between FRV/PBF and scintigraphy VQ

Patient #	Ventilation (FRV)		Perfusion (PBF)	
	Corr. Coef.	p-value (FRV)	Corr. Coef.	p-value (PBF)
P1	0.87	0.005	0.93	0.0009
P2	0.93	0.0009	0.96	0.0002
P3	0.94	0.0006	0.93	0.0008
P4	0.95	0.0002	0.95	0.0002

Author Disclosure: T. Diwanji: None. S. Pokharel: None. S. Feigenberg: None. W. D'Souza: None. N. Mistry: None.

3733

A Comparison of Lung SBRT Using Volumetric Modulated Arc Therapy With Static Field IMRT

G. Kim, J. Uhl, A. Sandhu, and T. Pawlicki; *UCSD Medical Center, La Jolla, CA*

Purpose/Objective(s): Volumetric modulated arc therapy allows for fast delivery of stereotactic body radiation therapy (SBRT) delivery in lung cancer treatment. At our institution, SBRT lung patients are planned using either volumetric modulated arc therapy (VMAT) or Static Field IMRT