Materials and Methods: Using the CBCT of the XRAD225Cx preclinical irradiator, 8 tissue equivalent cylinders of known composition and density (Gammex RMI, Middleton, WI) were imaged at 40kVp. The HU variation was plotted versus the product p times Zeff that yielded to a monotonically increasing curve. Based on this relationship and the tissues defined in the ICRU-44 report, interpolated tissues were created for pZeff varying from 2 up to 27 with a 0.2 step. Tissue equivalent cylinders were irradiated with the XRAD225Cx (225kVp). Exit dose was measured with EBT3 films and compared to Monte Carlo (MC) calculations from our GATE model of the irradiator. On the CT images, tissue segmentation was performed either by manual assignation of the elemental composition provided by the manufacturer or by using the (HU, p, EC) method. Dosimetric impact of the (HU, p, EC) method was evaluated on mice CT comparing with manual segmentation for brain and femoral head irradiations.

Results: Tissue equivalent exit dose measurements relative to solid water varied from 1.13 (AP6 adipose) down to 0.36 (SB3 cortical bone). Max 2% deviation was found with MC dose calculation performed with manufacturer data and 4.3% with calculation performed with the (HU, p, EC) method. Mean deviations were respectively 1.1% and 1.8%. It must be noticed that the segmentation method was based on real human tissues defined in ICRU-44 whereas measurements were performed with substitutes with elemental composition slightly different from human tissue elemental composition. The (HU, p, EC) method applied on mice CT allowed the automatic definition of 125 tissues. Dosimetric impact of the (HU, p, EC) was significant for bony tissues (>25%).

Conclusions: A robust tissue segmentation method was developed for dose calculation in preclinical radiation therapy based on the (HU, pZeff) relationship. Our method was successfully tested by comparing exit dose measurements from materials of known composition with MC dose calculation. The method was applied on mice CT for brain and femoral head irradiation with significant dosimetric impact.

EP-1453
Urethra-sparing prostatic SBRT: extreme dosimetric optimization on rectal wall using an endorectal balloon
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Purpose/Objective: To estimate the dosimetric impact of an endorectal balloon (ERB) on rectal wall (Rwall) dose distribution when using extreme dose constraints during the optimization of urethra-sparing prostatic SBRT plans.

Materials and Methods: A total of ten CT 3D NDI prostate cancer patients, prospectively randomized in an European multicenter phase II trial of urethra-sparing SBRT, were simulated with and without a 100cc inflated ERB. Patients were treated with the ERB following a SBRT protocol of 36.25 Gy in 5 fractions of 7.25 Gy to the PTV. The dose prescribed to the prostatic urethra (urethral planning risk volume, uPRV) was reduced to 32.5 Gy. The dose was delivered with two full rotational volumetric modulated arcs. Ten plans with ERB and ten without (Vmatref) were first optimized until dose prescription and normal-tissue constraints (ranging from 50% to 100% of prescribed dose) specified in the protocol were reached. Additional optimizations based on these 20 Vmatref plans were calculated by adding dose constraints to the posterior Rwall (D50%, D100, and D200). Starting from Vmatref (with and without ERB), these dose constraints were lowered five times to obtain plans Vmat1 to Vmat5. A total of 120 plans were analyzed. The homogeneity index (HI) for the PTV and uPRV were calculated to determine which optimization better spared Rwall without degrading the coverage of target volumes. Dose-volume histograms were analyzed for Rwall. The mean number of monitor units (MU) per optimization degree was recorded.

Results: HI for PTV remained quasi-constant with and without ERB from Vmatref until Vmat5 (HI=0.091±0.013 with ERB vs. 0.079±0.012 without) and then slightly degraded. HI for uPRV started at 0.083±0.026 for Vmatref with ERB vs. 0.094±0.025 without, and constantly deteriorated with higher optimizations. For the dose range [8-16 Gy], Vmat3 spared 20 to 27% more Rwall volume than Vmatref. The mean number of MU increased from Vmatref (2028±726) to Vmat5 (2582±877) and then dropped off for Vmat5 due to unreachable dose constraints.

ERB vs. no ERB: All plans were similar in the high dose regions [24-36 Gy] with a dose ratio ERB/noERB of [1.00-1.04]. Intermediate dose regions [12-24 Gy], dose ratio were below 1 for Vmatref [0.94-0.97], close to 1 for Vmat1,2 and range [1.04-1.07] for Vmat3. In low dose regions [2.5-12 Gy] all plans without ERB spared better the Rwall. In very low dose regions [0-2.5 Gy], plans with ERB were advantageous (dose ratio=0.80).

Conclusions: Extreme optimization on Rwall is feasible for urethra-sparing SBRT without compromising PTV dose homogeneity. Dose constraints to the posterior Rwall are now added during the optimization process though without knowing the potential benefit on rectal toxicity reduction. The ERBs do not seem to decrease the high dose received by the Rwall but may help to the intrafraction reproducibility of volume and shape while on treatment.

EP-1454
Eliminating dosimetric uncertainties in tomotherapy delivery in sarcoma patients using Monte Carlo techniques
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