Materials and Methods: Using the CBCT of the XRAD225Cx preclinical irradiator, 8 tissue equivalent cylinders of known composition and density (Gammex RMI, Middelton, WI) were imaged at 40kVp. The HU variation was plotted versus the product ρ 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 ρZeff 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, ρ, EC) method. Dosimetric impact of the (HU, ρ, 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, ρ, 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, ρ, EC) method applied on mice CT allowed the automatic definition of 125 tissues. Dosimetric impact of the (HU, ρ, 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, ρZ_{eff}) 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 cT1/3a N0 M0 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 ($Vmat_{ref}$) 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 $Vmat_{ref}$ plans were calculated by adding dose constraints to the posterior Rwall ($D_{3\%}$, $D_{10\%}$ and $D_{20\%}$). Starting from $Vmat_{ref}$ (with and without ERB), these dose constraints were lowered five times to obtain plans $Vmat_1$ to $Vmat_5$. 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 $Vmat_{ref}$ until $Vmat_3$ (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 $Vmat_{ref}$ with ERB vs. 0.094±0.025 without, and constantly deteriorated with higher optimizations. For the dose range [8-16 Gy], $Vmat_3$ spared 20 to 27% more Rwall volume than $Vmat_{ref}$. The mean number of MU increased from $Vmat_{ref}$ (2028±726) to $Vmat_4$ (2582±877) and then dropped off for $Vmat_5$ 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]. In intermediate dose regions [12-24 Gy], dose ratio were below 1 for $Vmat_{ref}$ [0.94-0.97], close to 1 for $Vmat_{1,2}$ and range [1.04-1.07] for $Vmat_3$. 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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Purpose/Objective: Superficial PTVs that extend close to or even involve the skin pose great difficulty for inverse planning algorithms. There is known uncertainty in build up and surface doses in treatment planning systems. To address this problem, a typical clinical protocol may consist of PTV-cropping or adding bolus. The rationale for this is to ensure a more accurate dose calculation near the surface and adequate coverage of the PTV. In attempting to cover the build-up region the optimizer can result in a solution that leads to excess fluence delivered by tangential beam segments near the surface. Patient motion or setup errors that bring the target into the region of high fluence, may lead to excess dose near the patient's skin. The goal of this study is to optimize PTV-cropping or bolus thickness so as to (1) achieve optimal coverage of the PTV and (2) dampen the effect of excess tangential fluence associated with inversely-planned helical tomotherapy treatments.

Materials and Methods: We used a commissioned Monte Carlo (MC) model of the helical tomotherapy unit within the McGill Monte Carlo treatment planning (MMCTP) system to recalculate tomotherapy optimized plans in sarcoma patients. The model consists of an accurately benchmarked accelerator model including the binary MLC coupled to a EGSnrc/dosxyznrc calculation of the patient dose distribution in a CT representation. Five patients were MC recalculated in planned setup and with introduced setup error obtained from the daily MVCT imaging.

Results: Fig. 1a shows the surface dose along the blue line for a: (1) tomotherapy plan, (2) MC recalculated plan, and (3) MC recalculated plan with introduced setup error. The tomotherapy skin dose is overestimated by 12% compared to the MC recalculated dose. The dose in proximity to the surface is increased by 10% with respect to the tomotherapy dose due to excess fluence near skin if setup errors on the order of 5 mm are considered. Fig. 1b shows the surface dose along the blue line with 1 cm bolus for the: (1) tomotherapy plan, (2) MC recalculated plan. The tomotherapy skin dose is overestimated by only 2% compared to MC. The use of bolus also eliminates skin overdose caused by setup errors and excess fluence (data not shown).

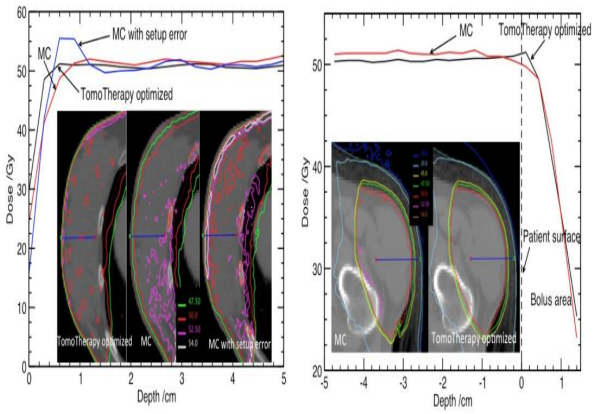

Fig 1 Skin doses for two sarcoma patients (a) with PTV cropping 3 mm from skin; (b) using 1 cm water equivalent bolus

Conclusions: We used accurate MC calculations to (1) design treatment planning strategies that improve plan robustness with respect to patient motion and setup errors; (2) evaluate the use of 'planning-bolus' (bolus used only for planning and not for treatment) and the actual delivered dose to the PTV in the patient treated with no bolus; (3) evaluate the necessary buildup or PTV cropping so that the dose to PTV is accurately calculated and the excess fluence near patient's surface is dampened. Our study shows that the amount of overlying material on the PTV must be at least 5 mm (by PTV cropping or bolus). A 'planning bolus' strategy improves plan robustness and eliminates excess fluence. PTVs cropped less than 4 mm from skin are sub optimally covered.

EP-1455

Accuracy of volume reconstruction and calculation with different external beam treatment planning systems

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Purpose/Objective: To determine 3D reconstruction volume calculation in several modern external beam radiotherapy treatment planning systems, with focus on stereotactic radiosurgery.

Materials and Methods: Five SRS patients were selected and contoured using BrainLab iPlan (volume is evaluated in contouring and planning tasks). GTV, CTV, PTV and organ at risks were contoured, exported using DICOM protocol, and imported in Varian Eclipse v.10, Philips Pinnacle v.9.8, Elekta Oncentra v.4.1 (manual and automatic customization) and Monaco v.3.3 (contouring and planning tasks) , Mobius3D v.1.3 and one non clinical use software (CERR v.3.3). Volumes (cm3) were calculated for reconstructed 3D contours in every TPS and then compared using mean, maximum and minimum volume between TPSs calculated volume and mean calculated volume.

Results: Figure 1 summarize results for different TPS and clinical structures of different volumes. Higher spread of volume calculation is found in smaller volumes, mainly due to volume grid calculation, differences in voxel assignments and first and last contour management. This differences reach as much as 60% of mean volume for some TPSs for volumes