PO-0893
Robustness of biologically-based treatment planning for prostate cancer patients
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Purpose/Objective: The use of biological information on tumour control and normal-tissue complications for treatment plan optimisation is a first step towards individualised radiotherapy. However, the robustness of the underlying models for tumour control probability (TCP) and normal-tissue complication probability (NTCP) needs to be analysed prior to any clinical application.

Materials and Methods: This work investigates the robustness of the TCP and NCTP models implemented in the biological optimisation tool of Eclipse for the case of prostate cancer. The CT images and structure sets of ten patients previously treated with helical tomotherapy were imported in Eclipse and several biologically-based IMRT plans were created for each patient (dose prescription: 72 Gy in 40 fractions). The plans were optimised by using the NTCP Lyman model for rectal bleeding and bladder contracture as objective and by putting physical constraints to the PTV so that the tumour coverage was comparable to that achieved with TomoTherapy®. The NTCP model parameters were then varied individually within the ranges found in the literature. Among others, the values of \( D_{50m} \), \( n \), and \( m \) were varied for the NTCP model, for both rectum and bladder. Finally, a VMAT plan was calculated for each patient. This plan was optimized in order to achieve tumour coverage and DVH goals comparable to those of the original tomotherapy plan.

Results: The results of this plan comparison study show that the NTCP Lyman model implemented in Eclipse is robust with respect to variations of the parameters \( m \) and \( n \) (representing slope and dose-volume parameter, respectively), while changes of \( D_{50m} \) (within 10 %) already resulted in significant DVH variations. The DVH goals for rectum and bladder remained within the limits recommended by the QUANTEC survey, although \( V_{rd} \) for the rectum was systematically higher than in the tomotherapy and VMAT plans. Remarkably, for each patient, the dose hot spots for rectum and bladder were significantly reduced (down to 99-102 % of the prescribed dose) in all biologically-optimised plans. Moreover, it was observed that the optimisation time was lower than for the VMAT plan and that extra contouring for the organs at risk overlapping with the PTV was redundant.

Conclusions: Biologically-based optimisation tools allow for individualised dose concepts and, in principle, could be safely used for treatment planning of prostate cancer. They have the advantage of reducing optimisation time, contouring process, and dose hot spots. However, the NTCP model parameters, especially \( D_{50m} \), should be known with uncertainties lower than 10 % and the DVH goals carefully verified. Further studies for dose prescriptions up to 80 Gy are currently being carried out.

PO-0894
Patient specific 3D dose calculation for 177Lu treatment of neuroendocrine tumours using the Raydose MC code
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Purpose/Objective: Peptide receptor radionuclide therapy (PRRT) with 177Lu labelled DOTATATE is increasingly used in the treatment of neuroendocrine tumours (NET) and other tumours expressing type 2 somatostatin receptors. In PRRT the kidney is generally the dose-limiting organ because low molecular weight radionuclide conjugates are mainly excreted by the kidney, where a fraction is reabsorbed, leading to a high locally absorbed dose. The second critical organ in PRRT is bone marrow whose dosimetry is usually determined from the activity concentration in the blood. Dosimetry in radionuclide therapy is commonly based on the MIRD model at the organ level (although MIRD also provides a voxel level scheme) which is not based on specific patients anatomy and tracers kinetics data and which can not provide 3D dose volumes. The aim of this work was to evaluate the feasibility of using a more accurate, patient specific, 3D dose calculation method in PRRT that could also take into account specific patient kinetic data.

Materials and Methods: The eleven patients enrolled in this study were treated with 177Lu-labeled peptides for neuroendocrine tumours. The mean administered activity per cycle was \( 5.7 \pm 1.2 \) GBq. All patients underwent a series of five sequential SPECT-CT scans at 1, 4, 24, 44, 72 h post-injection to evaluate the bio-distribution of the compound as a function of time. The SPECT-CT scanner (Symbia T2, Siemens Medical, Germany) was calibrated for absolute quantification of 177Lu using reference phantom measurements. Sequential SPECT-CT scans were registered to the first CT scan position. A deformable image registration algorithm was used to register all the anatomical scans of the sequential CT in the same frame of reference. The activity distribution in each SPECT scan were modified accordingly, using the generated deformation maps. 3D dose calculations were carried out using the Raydose MC code which has been specifically designed for molecular radiotherapy. Conventional radiotherapy plan evaluation metrics such as Dose Volume Histograms (DVHs) were generated for the kidneys, both average and maximum dose were extracted from the 3D dose map and were compared with the mean organ level MIRD calculations carried out with the Olinda/EXM software.

Results: The SPECT activity scans reported in counts per voxel were converted in activity concentration (BQ/mL) using reference phantom measurements. Sequential SPECT-CT scans were registered to the first CT scan position. A deformable image registration algorithm was used to register all the anatomical scans of the sequential CT in the same frame of reference. The activity distribution in each SPECT scan were modified accordingly, using the generated deformation maps. 3D dose calculations were carried out using the Raydose MC code which has been specifically designed for molecular radiotherapy. Conventional radiotherapy plan evaluation metrics such as Dose Volume Histograms (DVHs) were generated for the kidneys, both average and maximum dose were extracted from the 3D dose map and were compared with the mean organ level MIRD calculations carried out with the Olinda/EXM software.

Results: The SPECT activity scans reported in counts per voxel were converted in activity concentration (BQ/mL) using a calibration factor measured in standard conditions using a cylindrical phantom homogeneously filled with 177Lu. Raydose calculations were validated in these standard conditions within 5% of the expected nominal dose. Raydose patient dose calculations were carried out on a Dell PowerEdge R620 dual core Xeon E-26XX processor machine and took, on average, 30 minutes per scan per patient to complete with a statistical uncertainty of +/- 2% per voxel. Activity integration at the voxel level was carried out.
deforming the sequential activity maps using registered sequential SPECT-CT scans and with the parallelogram method. In 9 out of 11 cases the Olinda/EXM calculations of average dose absorbed by the kidneys was below the dose calculated by Raydose (range [8, 51]%). In 2 cases the kidney average dose, as calculated with the Olinda/EXM method, were below the dose calculated with Raydose (-6.26%). DVHs and 3D dose maps provided valuable information regarding the uniformity of the dose distribution which would have been otherwise missed with an organ level approach.

Conclusions: Following the experience obtained in this pilot study we conclude that it is feasible to implement in routine delivery of PRRT therapy patient specific 3D dose calculation using Raydose. Our workflow included deformable image registration to accurately account for changes in both patients anatomy and activity distribution during the course of the therapy. Work is in progress to use Raydose to optimise PRRT treatments in terms of fractionation, combination of isotopes and correlation with toxicity data.

Conclusions: 11 prostate SBRT patients treated in our clinic were localized using two USIG systems which showed average agreement to less than 0.5 mm in all three principle directions (LR, AP, SI). Intra-fraction tracking allowed us to reduce treatment planning margins to 3 mm posteriorly and 5 mm elsewhere, due to the ability to track and correct for motion during treatment.

PO-0895
3D transperineal ultrasound image guidance methods for prostate SBRT radiotherapy treatment
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Purpose/Objective: A second generation 3D ultrasound image guidance (USIG) system (Clarity, Elekta Inc), which allows for transperineal (TP) localization and intra-fractional tracking of the prostate has been evaluated for use in stereotactic body radiation therapy (SBRT) of the prostate at our institution. Here we describe our implementation of a prostate SBRT TP USIG protocol.

Materials and Methods: After the development of an initial clinical USIG based workflow for standard fractionation treatment, we extended the workflow to allow for increased positional verification required for SBRT. Our SBRT treatment protocol gives 36.25 Gy in 5 fractions, every other day and utilizes USIG to ensure target coverage. The planning target volume (PTV) is defined as the CTV plus a 3 mm margin posteriorly and 5 mm in all other dimensions. Patient alignment has to be approved by a physicist and a physician, both of whom have to be experienced in reading US images. During intra-fractional US-tracking, corrective action is taken if the target migrates more than 3 mm for more than 5 seconds in any of three orthogonal coordinates. Patients were positioned according to SBRT protocol and aligned to skin marks using treatment room lasers. TP USIG was performed and shifts from tattoo were performed and recorded. For purpose of redundant verification, a transabdominal (TA) USIG was performed (BAT, Nomos Inc.) while TP USIG tracking was on. Treatment was conducted using TP USIG tracking.

Results: A total of 57 fractions delivered to 11 prostate cancer patients were retrospectively analyzed for workflow performance, patient motion and agreement between two US image guidance devices (TA and TP). The mean of initial USIG shifts from skin marks based on TP positioning for all 11 patients was 0.24, 1.25, and -4.38 mm in left-right (LR), anterior-posterior (AP), and superior-inferior (SI) directions respectively. The average difference between the two US systems (TP vs TA) for all patients was -0.05, -0.02, and -0.04 mm in LR, AP and SI directions respectively. The respective standard deviations were 0.14, 0.34 and 0.27 mm. Patient alignment was corrected if indicated by tracking. Intra-fractional tracking data was analyzed and will be presented (see Image 1).

PO-0896
Radiotherapy quality assurance in the NIHR ProtecT trial
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Purpose/Objective: ProtecT is a phase 3 clinical trial [1] comparing prostate cancer mortality for patients with clinically localised prostate cancer randomly assigned to active monitoring, radical prostatectomy or 3D conformal external beam radiotherapy.

Trial results are anticipated for 2016 and the purpose of this work is to assess the quality of treatment plans produced for participants randomised to receive radiotherapy. 3D conformal external beam radiotherapy was used to deliver 74 Gy to the isocentre in 2 Gy fractions in 2 phases. During phase 1 a dose of 56 Gy was prescribed to a target volume including prostate and seminal vesicles and during phase 2 a dose of 18 Gy is prescribed to a target volume surrounding prostate only. To ensure consistency and comparability of radiotherapy between centres a detailed radiotherapy protocol was developed. To assess the quality of radiotherapy plans, 13 quantities were measured and a deviation recorded.