Carlo Plan (SMCP) [2]. The inverse treatment planning process starts with the definition of the SSD, the gantry angle and the collimator rotation for each electron field. Then the DAO is initiated and a potential aperture or energy change is determined. A cost function (cf) which determines the squared dose differences in all voxels of the PTV and the OARs between the actual value and a given upper or lower limit is to be minimized. The actual dose distribution has to be determined efficiently in each iteration step. For this purpose, the inverse electron treatment planning has been divided into a grid of beamlets for which the dose distribution has been pre-calculated using eMC [3]. Hence, the update of the dose distribution is realized by adding or subtracting the corresponding beamlet dose distributions. After DAO the final apertures have been set up as MLC shaped fields. To correct for the MLC impact on the dose distribution which has not been accounted for during the DAO, post processing steps are carried out by a weight optimization or adjusting the MLC apertures. The inverse treatment planning has been tested using a water phantom containing an artificial PTV and a distal OAR.

Results: The DAO converged after about 2000 iterative steps which corresponds to 25 minutes. In about 15% of the steps, the changes required to achieve a weight optimization or adjusting the MLC apertures. The DAO accounted for during the DAO, post processing steps are carried out by weight optimization or adjusting the MLC apertures. The inverse treatment planning has been tested using a water phantom containing an artificial PTV and a distal OAR.

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have benefitted greatly from these interactions. Results of our collaboration can be seen in the ROSIS project and associated short courses, involvement in clinical audit as members of the multidisciplinary team and several joint publications. It is a great honour to receive this award and I am delighted to ‘finally’ be a physicist albeit it an honorary one – but maybe that is even better!

AWARD LECTURE: COMPANY AWARD LECTURES

OC-0285
Motion simulations with a statistical deformation model to evaluate PTV margins in locally advanced prostate cancer
1Aarhus University Hospital, Department of Oncology and Medical Physics, Aarhus, Denmark
2Haukeland University Hospital, Department of Medical Physics, Bergen, Norway
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5Aarhus University Hospital, Department of Oncology, Aarhus, Denmark

Purpose/Objective: Radiotherapy of several major tumour sites involves simultaneous treatment of multiple targets, typically occurring when irradiation of both the primary and elective targets is indicated. In the treatment of locally advanced prostate cancer, the dominating residual geometrical uncertainties following image-guidance can be ascribed to deformations and uncorrelated motion of the involved targets: the prostate (CTV-p), the seminal vesicles (CTV-sv) and the pelvic lymph nodes (CTV-ln). The aim of this study was to use a statistical deformation model to simulate target motion throughout a course of treatment in this clinical scenario, for the purpose of margin evaluations.

Materials and Methods: The study was based on target delineations for 19 patients, all with a CT-set consisting of one planning and 9-10 repeat CTs. After rigidly aligning the repeat CTs to the planning CT based on intra-prostatic markers, the displacement vectors between the target shapes in the planning CT and those in the repeat CTs were calculated with deformable registration. For each patient, a motion model based on principal component analysis (PCA) of these displacement vectors was created. From this model statistical meaningful inter- and extrapolations of the delineated target shapes were made to construct new target shapes according to their probabilities of occurrence and without prior assumptions of the relative importance of the different motion and deformation patterns. Maximally conformal synthetic dose distributions were created for various uniform CTV-to-PTV expansions in the planning CT. For each patient, the motion model was employed to analyse target coverage distributions for 1000 simulated treatment courses on each of these synthetic dose distributions.

Results: Simulations of inter-fractional motion resulted in 7, 10 and 18 patients with an estimated average accumulated dose of at least 95% of the prescribed dose to 99% of the CTV (D99), for uniform margins around the prostate of 3mm, 4mm and 5mm, respectively. For the seminal vesicles and the pelvic lymph nodes, margin expansion of 3mm, 5mm and 9mm resulted in 1, 11, 15, 16 and 8, 18, 18, 18 patients respectively with an expected average D99-95% of the prescription. In Figure 1, the estimated average D99 including the10%-90%-percentiles for each target are shown.

Conclusions: We have developed a deformable registration based motion simulation model and successfully applied this on a comprehensive repeat CT data-set. For the patients included in this study, 90% had full target coverage with CTV-to-PTV expansions of 5mm for the prostate, 11mm for the seminal vesicles and 5mm for the pelvic lymph nodes.

OC-0286
Radiobiological implications of respiratory motion in the treatment of lung cancer
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Purpose/Objective: Respiratory motion introduces complex spatio-temporal variations in the dosimetry of radiotherapy and may contribute to uncertainties in radiotherapy planning. This novel in vitro study investigates the potential radiobiological implications occurring due to tumour motion in lung cancer radiotherapy.

Materials and Methods: A bespoke phantom and motor-driven platform to replicate respiratory motion and study the consequences on tumour cell survival in vitro was constructed. Human non-small cell lung cancer cell lines (H460 and H1299) were irradiated in uniform (0-8Gy) and modulated radiotherapy fields (4Gy) in the presence and absence of respiratory motion (14 and 21 respirations/minute). Clonogenic survival was calculated for irradiated and shielded regions. Direction of motion, replication of dosimetry by MLC manipulation and oscillating lead shielding were investigated to confirm differences. Differences were compared using the Mann-Whitney test.

Results: No difference in survival was seen for cell lines uniformly irradiated with or without motion. With respiratory motion survival was significantly higher for out-of-field regions for H460 and H1299 compared with static irradiation of 50% of the flask (p<0.0005). Significantly higher survival was found in the in-field region for the H460 cell line (p<0.03). Oscillating lead shielding also produced these significant differences. MLC and perpendicular motion had no significant difference compared to static irradiations.

Conclusions: These data indicate that respiratory motion can impact on in- and out-of-field survival in the presence of non-uniform irradiation for lung cancer cell lines. This may have implications for the efficacy of radiotherapy particularly in areas where tumour is missed due to respiratory motion.

OC-0287
Beyond VMAT - high speed delivery of rotational IMRT with cone-beam tomotherapy
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2Aarhus University, Department of Radiation Oncology, Aarhus, Denmark

Purpose/Objective: Radiotherapy of several major tumour sites involves simultaneous treatment of multiple targets, typically occurring when irradiation of both the primary and elective targets is indicated. In the treatment of locally advanced prostate cancer, the dominating residual geometrical uncertainties following image-guidance can be ascribed to deformations and uncorrelated motion of the involved targets: the prostate (CTV-p), the seminal vesicles (CTV-sv) and the pelvic lymph nodes (CTV-ln). The aim of this study was to use a statistical deformation model to simulate target motion throughout a course of treatment in this clinical scenario, for the purpose of margin evaluations.

Materials and Methods: The study was based on target delineations for 19 patients, all with a CT-set consisting of one planning and 9-10 repeat CTs. After rigidly aligning the repeat CTs to the planning CT based on intra-prostatic markers, the displacement vectors between the target shapes in the planning CT and those in the repeat CTs were calculated with deformable registration. For each patient, a motion model based on principal component analysis (PCA) of these displacement vectors was created. From this model statistical meaningful inter- and extrapolations of the delineated target shapes were made to construct new target shapes according to their probabilities of occurrence and without prior assumptions of the relative importance of the different motion and deformation patterns. Maximally conformal synthetic dose distributions were created for various uniform CTV-to-PTV expansions in the planning CT. For each patient, the motion model was employed to analyse target coverage distributions for 1000 simulated treatment courses on each of these synthetic dose distributions.

Results: Simulations of inter-fractional motion resulted in 7, 10 and 18 patients with an estimated average accumulated dose of at least 95% of the prescribed dose to 99% of the CTV (D99), for uniform margins around the prostate of 3mm, 4mm and 5mm, respectively. For the seminal vesicles and the pelvic lymph nodes, margin expansion of 3mm, 5mm and 9mm resulted in 1, 11, 15, 16 and 8, 18, 18, 18 patients respectively with an expected average D99-95% of the prescription. In Figure 1, the estimated average D99 including the10%-90%-percentiles for each target are shown.

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