Adaptive radiotherapy for advanced lung cancer ensures target coverage and decreases lung dose

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**Purpose or Objective:** Effective treatment options are needed for locally advanced lung cancer. Increased treatment precision and decreased treatment volumes are mandatory for more aggressive radiotherapy. Adaptive radiotherapy (ART) was implemented to adjust the treatment plan to positional or volumetric changes of the tumour, and to normal tissue changes like atelectasis. Recently, ART was shown to improve local control without increasing radiation pneumonitis [1]. The present study investigates the dosimetric consequences of ART for 235 patients.

**Material and Methods:** ART intervention rules were implemented for lung cancer patients treated with definitive chemo-radiotherapy, in concordance with smaller PTV margins and daily online soft-tissue matching. Intervention rules derived from geometrical criteria for normal tissue and tumour changes. Violation of these for three consecutive fractions triggered an evaluation. If the observed change was suspected to lead to an underdosage of tumour/lymph nodes or an overdosage of normal tissue, a CT rescan and a replan were made. The original plan was recalculated on the rescan to evaluate the consequence of replanning for patients receiving a plan adaptation in a cohort of 235 consecutive patients treated with ART. For the first 50 patients, in order to assess the efficacy of the intervention rules, two additional surveillance CT scans were acquired during the RT course and the treatment plans were recalculated on these scans. The change in lung dose due to the implementation of ART was found comparing the treatment plans of the first 50 ART-patients with 50 pre-ART-patients.

**Results:** Due to ART, the PTV decreased from 569 cm³ to 398 cm³, and consequently the mean lung dose decreased from 14.1 Gy (SE 0.6) to 12.6 (SE 0.6) Gy. The criterion for the need of adaptation was a decrease in target coverage of CTV>1% or PTV>3%. The cohort of patients with two need of adaptation was a decrease in target coverage of 14.1 Gy (SE 0.6) to 12.6 (SE 0.6) Gy. The criterion for the evaluation impossible. In 15 patients, target shrinkage or less replanned due to changes in atelectasis making match avoid overdosage of spinal cord. Three patients were the targets were seen. One patient was replanned in order to decrease and designates the reason for replanning. In five overall target coverage. Figure 1 shows the extent of ART had at least one replan. In total 77 adaptations were made. Fifty three adaptations corrected for a decrease in lung dose due to the implementation of ART-patients with 50 pre-ART-patients.

**Conclusion:** The implementation of soft-tissue match and ART secured high treatment precision and allowed safe margin reduction in terms of persistent target coverage. The reduced margins reduced the mean dose to the lung.


OC-0365
The need for anatomical landmarks in adaptive rectal cancer boost radiotherapy

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**Purpose or Objective:** In rectal cancer 15% of the patients show a pathological complete response (pCR) after neo-adjuvant chemoradiotherapy and these patients show better overall survival. To increase this pCR rate, in several studies a boost dose is given to the tumor. To safely deliver this boost, insight in the tumor position is needed. Currently, online imaging techniques provide no contrast of the tumor. However, since tumors are situated in the rectal wall, which is visible on online imaging like CBCT, the rectal wall position may be used as a surrogate for the tumor position. We therefore investigate the feasibility of tracking a part of the rectal wall close to the initial tumor as a motion surrogate for the tumor, to be used in online adaptive boost radiotherapy in rectal cancer.

**Material and Methods:** We scanned 16 patients daily on a 1.5T MRI scanner during a one-week short course of radiotherapy (5 times 5Gy). Rectum and tumor were delineated on the T2 weighted scan of each day. All scans were registered on bony anatomy, mimicking daily patient set-up. For both tumor and rectum separately, displacements from the first day to every other day were determined, by calculating per voxel the shortest distance to each delineation. To find out how proximate to the tumor we have to define our rectum motion surrogate, we selected that part of the rectum that lies within 1, 3, 5, 7 and 10 mm of the initial tumor (ProximateRectum). For each point on these ProximateRectums, we determined the nearest point of the tumor as corresponding point. Between all the corresponding points of ProximateRectum and tumor, the displacements to every day were correlated to each other. We also determined how much of the variance in tumor motion was explained by each ProximateRectum. These analysis were done for the 1, 3, 5, 7 and 10 mm ProximateRectum separately.

**Results:** Different motion patterns were found for tumor and ProximateRectums, especially when movement of the tumor is in cranial caudal direction, since no anatomical landmarks are available (see figure 1). We found correlations of p = 0.66, 0.64, 0.55, 0.53 and 0.45 (all p<001) for ProximateRectum of respectively 1, 3, 5, 7 and 10 mm. This
results in only 44%, 40%, 31%, 28% and 20% of the variance of tumor motion being explained by local rectum motion for respectively ProximateRectums of 1, 3, 5, 7 and 10 mm.

**Conclusion:** Even when the rectal motion surrogate is defined within 1 mm of the tumor, tracking this part of the rectal wall will not result in an accurate tumor positions since only 44% of the variance in tumor motion is explained by tracking the rectal wall. The lack of anatomical landmarks prevents finding the true rectum deformation and thus an accurate tumor position. Especially for motion in cranial-caudal direction, there is poor correlation between tumor and local rectal motion. Therefore, anatomical landmarks are needed for positioning the tumor e.g. direct imaging of the tumor using MRI or indirect imaging of the tumor using implanted markers.

**OC-0366**

**Dosimetric benefit of adaptive proton therapy compared to adaptive photon therapy in cervical cancer**

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**Purpose or Objective:** In cervical cancer, adaptive radiation therapy (ART) can be applied to compensate for interfraction target motion. However, organs at risk (OAR) still receive substantial dose when photon-based ART is applied. Adaptive proton therapy (APT) holds the promise to further limit OAR dose while maintaining adequate target coverage. Our aim was to investigate the potential dosimetric advantages of image-guided APT (IGAPT) compared with photon-based ART (IGART).

**Material and Methods:** Twelve cervical cancer patients treated with photon therapy were included in this retrospective study. Besides the clinically acquired full bladder planning CT, additional empty bladder planning CT and weekly repeat CTs were acquired for study purposes. Planning CTs were registered based on bony anatomy and multiple interpolated cervix-uterus structures were derived using a point-based non-rigid registration method. For each interpolated structure, a photon (VMAT) and a proton (IMPT) plan was created to build patient-specific plan libraries. All plans were robustly optimized with a prescribed physical CTV dose of 46 Gy-equivalent (GyE) (23 x 2 GyE) for pelvic irradiation or 50.4 GyE (28 x 1.8 GyE) for para-aortic irradiation. For each patient, repeat CTs were registered to the full bladder planning CT based on bony anatomy and IGART and IGAPT treatments were simulated by selecting library plans and recalculating the dose. For each simulated fraction, CTV coverage (V95% > 98%) was assessed and differences in Dmean and D2cc fraction dose and fractionated substitutes of V15Gy, V30Gy and V45Gy parameters (i.e. dose levels divided by the number of fractions) for bladder, bowel and rectum were evaluated and tested for significance (Wilcoxon signed-rank test). Also, fraction dose distributions were accumulated and differences in the overall rectum toxicity related DVH parameter (V30Gy) and normal tissue complication probability (NTCP) for grade 2 acute gastrointestinal toxicity were determined.

**Results:** In 6 fractions (10.7%), the cervix-uterus structure deviated substantially from the pre-treatment derived structures. Adequate CTV coverage was obtained in 92% (96%) of the remaining fractions for IGAPT (IGART) which resulted in adequate CTV coverage on average per patient. All DVH parameters for bladder, bowel and rectum, except for the fractionated substitute of rectum V45Gy, were improved using IGAPT (Figure). Also, the mean dose to bowel, bladder and rectum was reduced significantly (p<0.01). Compared to IGART, IGAPT indicated a mean reduction of 7% for rectum V30Gy and a mean decrease from 0.33 to 0.18 in bowel NTCP.

**Conclusion:** This study demonstrates the feasibility of IGAPT in cervical cancer using a plan library based adaptive strategy to compensate for interfraction target motion. Compared to photon-based IGART, IGAPT maintains adequate target coverage while a significant dose reduction in bladder, bowel and rectum can be achieved.

**OC-0367**

**A Neural Network analysis to support Adaptive RT strategies: a multicenter retrospective study**

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