Purpose or Objective: In the field of Adaptive Radiation Therapy (ART), non-linear transformation models should be considered to take into account complex motion and anatomic variations. In order to follow and then predict intra-organ dynamic, a novel voxel-by-voxel approach has been proposed using epidemic model. The susceptible-infected-susceptible (SIS) model was applied to radiotherapy treatments to predict morphological variations in the Head and Neck (H&N) region and to follow single voxel motion and warping.

Material and Methods: 360 daily MVCT studies of 12 H&N patients treated by Tomotherapy® were retrospectively analyzed. Deformable image registration (DIR) and automatic structures re-contouring were performed by RayStation® treatment planning system (TPS). The study focused on parotid glands (PG) identified by previously studies such as organs systematically affected by warping. Using the epidemic model, PG shrinkage was evaluated considering each voxel as a single subject and the deformed vector field (DVF) as an infection. A dedicated IronPython® script was developed to export daily coordinates and DVF displacements from the deformed mesh grid obtained by the TPS for each vertex of the region of interest (ROI) contouring. Finally, the SIS model was developed by a MATLAB® home-made simulation tool.

Results: The patients’ validation was obtained by splitting susceptible (S) and infectious (I) cases; 0.4cm of voxel displacement was set as clinical threshold within a [0±1cm] range of warping. Correlation between epidemic model and daily PG shrinkage was carried out by dynamic time warping (DTW) algorithm applied to the SIS parameters. A DTW distance of 2.39±0.66 was obtained setting the contact rate at 7.55±0.69 and the recovery rate at 2.45±0.26; birth rate was not counted in a constant population hypothesis. A physician’s multiple-blind evaluation confirmed that PG warping evolution could be predicted, applying the SIS model, in almost 65% of patients.

Conclusion: Combining epidemic model with ART and image systems can on-line support and validate daily setup and assess anatomical warping. In this novel approach, contrariwise to a time series analysis of the whole organ, specific and localized intra-organ variation could be detected. Moreover, integrating a dose accumulation evaluation, the SIS model could aid clinic decision making to suggest possible re-planning during the 6 weeks of therapy. A 3D model of the ROI can be generated and its evolution during the treatment course can be investigated.

EP-1807
Replanning effects in Tomotherapy treatment using dose accumulation and dose deformation strategies
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Purpose or Objective: Quantification of the delivered dose is one of the most important feature in inter-patient variability in radiation treatment. Difference between planned and accumulated doses contains different uncertainties due to set-up errors, patient movement and anatomy variations. Shrinkage of Parotid Glands (PG) in Head and Neck (H&N) patients is a major issue in accumulation of the delivered dose. This study investigates Target and Organs at Risks (OARs) variations during the treatment course and their dosimetric consequences. We evaluated the effect of replanning on the deformed structure during the course of treatment.

Material and Methods: Six patients with H&N cancer treated by Tomotherapy (SIB 66 Gy, 60 Gy, 54 Gy in 30 Daily Fractions) have been, retrospectively, enrolled. Through Planned Adaptive® software each delivered fraction have been recalculated on daily imaging to obtain the daily dose (DMVCT). Deformable image registration (DIR), using Raystation (v.4.7.2), have been performed to propagate the structures along the treatment course. The planned doses were mapped (DDVF) using the deformed vector field (DVF) matrix. The DVF obtained from the reverse DIR was used to deform DMVCT to match the planning kVCT; we obtain a voxel by voxel association of DMVCT in a single image dataset. DDVF and DMVCT were compared performing 3D-γ analysis (2 mm, 2%) to evaluate the agreement on 3D distribution and warped structures. Two replanning strategies were adopted during the 18th fractions: (1) re-plan on original target and deformed OARs (D18,OAR) and (2) re-plan on deformed target and deformed OARs (D18).

Results: DDVF and DMVCT did not show a good consistency (3D γ-passing rate = 85 ± 1 %, p<0.001). DDVF was significantly (p<0.01) lower than DMVCT in term of average doses in PG (12.2 ± 10.3 %). Smaller differences were founded in average doses to the PTVs (2.6 ± 1.3 %). γ-passing rate and dosimetric variation to PG and PTVs did not show relevant correlation (p>0.05). Parotid gland showed a systematic shrinking during the course of treatment quantifiable in about 4% volume reduction for week of treatment. Full accumulation of dose showed an increase of the average dose to PG of 3.0 Gy ± 3.3 Gy [-4.6 Gy ÷ +7.7 Gy]. PTV volume variations were negligible (4.7 ± 1.6 %). The average doses of the PTVs increase of 1.6 Gy ± 1.3 Gy [-0.5 Gy ÷ +3.4 Gy]. Retrospective re-planning analysis showed that in case of both Target and OARs deformation, 5 out of 6 (83 %) patients enrolled could had benefit from ART. By ART the PG average dose decreased -2.0 Gy ± 1.4 Gy [-3.8 Gy ÷ -0.2 Gy] in first replanning strategy (D18,OAR) and -3.2 Gy ± 1.7 Gy [-5.0 Gy ÷ -0.2 Gy] in case of both Target and OARs deformation (D18).
Conclusion: DDVF do not describe adequately the delivered dose in the patient. Difference between planned and delivered doses in PTVs is reasonable, conversely anatomical variations seems to be a cause of overdosage in PG. Re-planning on 18Th MVCT could brought significant benefits, in terms average dose of PG.

EP-1808
A biological modeling based comparison of two strategies for adaptive radiotherapy of bladder cancer

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Purpose or Objective: Several adaptive strategies have been implemented to account for anatomical changes during radiotherapy for bladder cancer. To obtain target structures, either the first four CBCT scans can be used (CBCT-based strategy), or the interpolation of bladder volumes on pretreatment CT scans (CT-based strategy). The purpose of this study was to determine whether the CBCT-based or CT-based strategy is more favorable in terms of tumor control probability (TCP) and normal tissue sparing.

Material and Methods: Ten patients from each of the two participating institutes were analyzed, adopting the clinically used adaptive strategy and dose prescription from each institute. With the CBCT-based strategy, a library of three plans was created, corresponding to a small, medium and large bladder. Patients received 70 Gy to the bladder tumor, 60 Gy to the non-involved bladder and 48 Gy to the lymph nodes, in 30-35 fractions. With the CT-based strategy, a library of five plans was created using two pre-treatment CT scans, with full and empty bladder, respectively. Patients received 55 Gy to the tumor and 40 Gy to bladder and lymph nodes, in 20 fractions.

Tumor control: TCP was calculated for the combined target volumes of tumor and bladder, using the Linear-Quadratic model with an α/β ratio of 13 Gy. Since tumor cell density in the non-involved bladder wall was unknown, it was varied between 10^2 and 10^7 cells/cm³. To investigate the effect of the different dose prescriptions, the TCP was recalculated for the CT-based strategy with the dose scaled to 70 Gy in 35 fractions.

Normal tissue sparing: for rectum and bowel cavity, the equivalent dose in 2 Gy fractions (EQD2) was calculated using α/β values of 5 and 8 Gy, respectively, and DVH parameters were extracted. In addition, the planning target volume for each chosen plan divided by the daily bladder volume was calculated. Differences in parameters between groups were assessed using a Wilcoxon signed-rank test.

Results: A higher TCP for the CBCT-based strategy compared to the CT-based strategy was found, independent of modeled cell density in the non-involved bladder wall (Figure 1). For a low cell density, median TCP for the CBCT-based strategy was 75%, compared to 49% for the CT-based strategy. These results were comparable to 3-year local control rates previously reported. In addition, scaling the dose from the CT-based strategy to 70 Gy increased the median TCP to 72%. For the CT-based strategy, a lower median rectum V30Gy and lower median bowel V45Gy compared to the CBCT-based strategy were observed (Figure 1). This difference is reflected in the finding that the PTV is on average 3.9 times larger than the daily bladder volume for the CBCT-strategy, compared to 2.2 times for the CT-based strategy (p<0.01).

Conclusion: Total bladder TCP is higher for the CBCT-based strategy, which is due to prescription differences. The adaptive strategy based on CT scans results in the lowest rectum V30Gy (EQD2) and bowel cavity V45Gy (EQD2).

EP-1809
Intrafractional patient movement during an online adaptive replanning procedure for cranial SRS

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Purpose or Objective: To investigate the patient’s movement during the preparation of an adaptive cranial radiosurgery (SRS) procedure and its dosimetric impact.