Impact of re-planning in a multi-center research network: A retrospective analysis of anonymized data.

Purpose or Objective: The retrospective analysis of anonymized data investigates the benefits of predictive analysis to assess the impact of dose variations in Adaptive Radiation Therapy (ART) for lung cancer patients. Within a multicenter research network, clinical outcome was evaluated to determine if re-planning is needed.

Material and Methods: The retrospective study enrolled 40 head and neck (H&N) anonymized data from Center-A (MVCT), 20 from Center-B (CBCT), 8 from Center-C (CBCT), and 8 from Center-D (CBCT). We have post-processed more than 2100 CT studies obtained by the imaging on board (>200000 slices). We analyzed parotid gland (PG) as organs most affected by warping during the weeks of therapy. Volume and dose were normalized to the first day of treatment in order to remove bias related to machine/images variability and anatomical dimension. Structures were re-contoured automatically and the doses deformation was performed by RayStation® within an automated ART workflow supported by IronPython® scripting. Using DIR algorithms and GPU fast computing, the daily setup images were analyzed and compared. To support the data-mining; a Neural Network (NN) tool was developed and implemented in MATLAB® to evaluate abnormal clinical cases and re-planning strategies during fractions.

Results: A weekly analysis was carried out to follow and predict variations. After 6 weeks of therapy, PG showed a mean volume decrease of 23.7±8.8%: 25.1±9.2% in Center-A, 23.8±6.6% in Center-B, 21.2±10.3% in Center-C, and 24.4±9.8% in Center-D. The NN analysis showed that, during the first 3 weeks, almost the patients' cohort followed a similar trend. Mean PG morphing can be predictable in 86.3% of the center cases: 89.6% A, 92.7% B, 76.0% C, 87.0% D. From the 4th week some challenges appeared. The patients that benefit from a review of the initial plan increased during treatment, highlighting the need for re-planning. Based on PG shrinkage, 53.5% of patients would need a re-planning with an inter-centers variability of 19.7%. An amount of 17.0% of cases is affected by bias due to algorithm and set-up error: 11.5% and 5.5% respectively.

Conclusion: IGRT and ART techniques ensure a personalization of patients' treatment. A predictive NN tool was implemented and trained in order to detect criticalities in a multi-centric study supporting the feasibility of national data-mining for ART purpose. Based on re-planning data and PG prediction, a mid-course re-planning could be scheduled in the 4th week to ensure an adequate dose distribution during the treatment course.

Material and Methods: 5 lung cancer patients were selected for analysis, all of whom had a re-simulation CT (rCT) scan performed on the same day as a CBCT scan during their radiotherapy treatment. For each patient, two CBCT reconstructions were computed and used for dose calculation. The first CBCT was a clinical 3D reconstruction of the CBCT images as acquired for image guided radiation therapy (IGRT). This study demonstrates that a post-processing of the raw projection data can improve the CBCT image quality such that the accuracy of CBCT based dose calculations can be recovered.

Purpose or Objective: Cone beam CT (CBCT) based dose calculations are inaccurate due to the image quality of CBCT images acquired for image guided radiation therapy (IGRT). This study demonstrates that a post-processing of the raw projection data can improve the CBCT image quality such that the accuracy of CBCT based dose calculations can be recovered.

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Although the rCT and CBCT images were acquired on the same day, setup errors and anatomical differences such as diaphragm and chest wall position were evident when the CBCT images were compared with the rCT. Therefore, deformable image registration was performed with elastix, to eliminate dose differences due to anatomical differences between the scans. Missing anatomy in the CBCT images due to the limited field of view was copied from the rCT image after deformable registration of the CBCT images.

The original treatment plan was recalculated on the rCT, CBCT, and iCBCT image sets using Pinnacle ver. 9.10. The resulting dose matrices were compared using a 2%/2mm and 1%/1mm gamma analysis with the rCT dose as reference dose. The dose criterion was evaluated as 2% (1%) of the prescribed dose of 66 Gy. A low dose threshold of 10% of the prescription dose was used, and the gamma analysis was only performed in the CBCT volume.
Results: High gamma pass rates were achieved. The cCBCT-based doses resulted in 2%/2mm gamma pass rates between 89.4 and 96.4%, while the iCBCT-based doses resulted in gamma pass rates between 96.4 and 100%. The 1%/1mm gamma analysis yielded pass rates between 77.5 and 80.3% for the cCBCT images, while the iCBCT images provided pass rates between 90.7 and 98.7%. For all patients, the iCBCT images provided superior pass rates compared to the cCBCT images. The table below shows all gamma pass rates for the 5 patients.

<table>
<thead>
<tr>
<th>γ-criterion</th>
<th>Image</th>
<th>Pt 1</th>
<th>Pt 2</th>
<th>Pt 3</th>
<th>Pt 4</th>
<th>Pt 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%/2mm</td>
<td>cCBCT</td>
<td>89.4%</td>
<td>96.4%</td>
<td>95.8%</td>
<td>94.7%</td>
<td>98.1%</td>
</tr>
<tr>
<td></td>
<td>iCBCT</td>
<td>100%</td>
<td>98.4%</td>
<td>99.9%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>1%/1mm</td>
<td>cCBCT</td>
<td>77.5%</td>
<td>80.3%</td>
<td>77.6%</td>
<td>79.9%</td>
<td>79.5%</td>
</tr>
<tr>
<td></td>
<td>iCBCT</td>
<td>98.7%</td>
<td>90.7%</td>
<td>98.6%</td>
<td>98.6%</td>
<td>95.1%</td>
</tr>
</tbody>
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Conclusion: CBCT images can recover the image quality necessary for accurate dose calculations through comprehensive artefact corrections. While the iCBCT doses are accurate, further studies are required to determine how this result can be translated into clinical practice where the accurate dose calculation has potentials within adaptive radiotherapy and CBCT-based online planning. The present study is an important step towards the routine use of CBCT images for adaptive radiotherapy.

Proffered Papers: RTT 4: How to increase the knowledge for patients and staff

OC-0369 Video glasses to reduce claustrophobic anxiety in radiotherapy treatment
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Purpose or Objective: To investigate whether video glasses can reduce the anxiety level in claustrophobic patients in radiotherapeutic treatment. Claustrophobic patients experience a high level of stress and discomfort which can hamper therapeutic procedures and possibly lead to non-optimal treatment. The influence of video glasses (Luna5, Cedexis Inc.) on stress level during radiotherapy was measured using the Beck Anxiety Inventory (BAI) and biometrical parameters.

Material and Methods: In radiotherapy, systems may be equipped with a tight bore (CT, Tomotherapy) and the patients are immobilized on the treatment couch. A mild to moderate level of anxiety due to claustrophobia occurs at 10% of the population, a more severe level occurs at 4%. The common method to deal with a claustrophobic patient is to spend time with the patient to simulate treatment or to prescribe a tranquilizer. The idea of the video glasses is to focus patient attention to a movie using images and sounds from nature (‘Beter door Beeld’ Inc.). Volunteers (n=15) underwent a simulation of a radiotherapy treatment on the Tomotherapy system. Each volunteer filled in the BAI form in advance, which estimates the severity of their anxiety, based on a past individual claustrophobic experience. Severe level of anxiety was present in 11 volunteers, moderate level was found in 4 volunteers. Each volunteer was exposed to 3 runs: one without glasses, one with and the third without to measure a possible effect on habituation. The glasses were placed when the volunteer was on the couch (no immobilization). The volunteer was positioned in the bore of the Tomotherapy system and left alone during 2 minutes. After each run the volunteer filled in the BAI form with reference to the anxiety felt during the last run. Moreover, the volunteer was monitored continuously during each run using the Nexus-10 biofeedback system (MindMedia Inc.) to access the experienced level of anxiety more objectively. Results shown here are based on the detection of the high beta EEG wave.

Results: Reduced level of anxiety (based on the BAI score) was indicated by 13 out of 15 volunteers when using video glasses (see figure 1). This was confirmed by the observed trend in the ‘high beta’ brain wave amplitude. This brain signal is associated with stress level. The difference in mean amplitude of this wave between the run with and without video glasses is depicted in figure 2.

Conclusion: Using video glasses with an especially composed movie using images and sounds from nature during radiotherapy treatment, clearly lowers the level of anxiety of claustrophobic volunteers both subjectively based on the questionnaire as objectively by biometric measurements. Feedback of the volunteers overwhelmingly expressed a preference to undergoing treatment with video glasses: “it was much easier to relax, never without glasses!”

OC-0370 The influence of virtual training on pelvic radiotherapy education for the multidisciplinary team
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Purpose or Objective: Radiotherapy accelerates rapidly and ongoing training is essential to maintain and develop knowledge. A virtual reality environment is one way to provide training. This study aims to demonstrate how a training package for advanced prostate and cervix radiotherapy can be implemented effectively in a multi-disciplinary setting using a virtual reality environment.

Material and Methods: The training package consists of a virtual reality training tool (visual demonstration) and workbooks (self-filled questions). Each training tutorial is delivered by a senior radiographer and includes identification of pelvic anatomy, review of different radiotherapy treatment planning and delivery techniques (conformal, static field intensity modulated radiotherapy and volumetric modulated radiotherapy), image guided treatment scenarios and radiotherapy related side effects. The trainees were asked to complete pre and post tutorial questionnaires by grading their knowledge from 1 not confident at all, to 10 being exceptionally confident. These were devised to assess the effectiveness of the training