OC-0253
Mid-treatment adaptive dosimetry of swallowing organs at risk(SWOAR) in head & neck cancer patients undergoing VMAT
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Purpose/Objective: Modern radiotherapy techniques such as IMRT and VMAT allow physicians to spare organs at risk of radiotherapy damage thereby improving quality of life (QoL) amongst survivors. In patients undergoing radical radiotherapy (RT) for head and neck cancer, dose to SWOAR is increasingly being recognised as a determinant of QoL and long-term function such as dysphagia, regurgitation and tube dependency. Therefore, it has been proposed that limiting dose to SWOAR would be a desirable goal. However, there is no data on dosimetry of SWOAR during treatment or whether changes are potentially due to tumour response or inflammation thereby, supporting a strategy of enforcing strict dose constraints. This study aimed to document dosimetry of SWOAR using midway planning CT scan, whilst applying the original treatment plan as well as an adaptive plan generated de novo.

Materials and Methods: 27 consecutive patients with head and neck cancer were CT-simulated (SCAN 1) and a VMAT treatment plan (PLAN1) was generated to treat to a dose of 65Gy in 30 fractions (9). Patients completed treatment based on this plan.

Mid-treatment ie week 3, patients underwent a second CT-simulation to acquire mid treatment planning image (SCAN2)

Retrospectively, the original treatment PLAN 1 was applied to the mid-treatment SCAN2 to create PLAN 2

In addition, a de novo plan or PLAN (ART) was generated using SCAN 2 but with the optimisation priorities and constraints unchanged from the first PLAN (this second plan was aimed to treat last 10 treatments to 21.67Gy in 10f)

Delineation of SWOARs was performed for Base of tongue (BOT), oesophageal inlet muscle (EIM), superior/middle/inferior pharyngeal constrictor constrictor muscle (SPCM/MPCM/IPCM), cricopharyngeal muscle (Crico), cervical oesophagus (Ceso), supra-larynx and glottic larynx for both treatment planning SCAN 1 and SCAN 2 and mean and median dose to each SWOAR was calculated.

A paired t-test was used to compare the dose to SWOAR between PLAN1 (clinical plan 30f) and PLAN1(20f) PLAN1(20f) to identify if there was a significant difference when a recalculaiton was performed and delivered for remaining 10f. This was repeated to evaluate a significant difference when PLAN ART was to be used for remaining 10f.

Results: Overall there was little difference in dosimetry to SWOAR whether treatment proceeded using the original plan recalculated (PLAN 2) or an adaptive plan generated de novo to optimise for PTV coverage (PLAN ART). The only significant difference was seen for Crico p=0.04, SPCM p=0.01 and EIM p=0.04 for PLAN 2 and for the Crico p=0.01 for PLAN ART used in conjunction with an adaptive plan.

Conclusions: This study showed delineation and evaluation of dose to SWOAR at the initial planning stage was a reasonably good estimation of expected dose throughout treatment. Therefore applying treatment planning constraints at the outset, would be a reasonable strategy to reduce dose to SWOAR. Our data reveals there may be some concern over the variance in dosimetry to the cricopharyngeal muscle, superior inferior pharyngeal constrictor muscle and esophageal inlet muscle over the course of RRT treatment.

OC-0254
Comparison of planned dose distribution for gated IMRT of lung cancer with different gating windows
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Purpose/Objective: Respiratory motion limits the efficacy of intensity modulated radiation therapy (IMRT) as larger treatment fields are required to prevent geographic misses. With respiratory-gated RT, the irradiated lung volume is reduced by the selection of beam-on-phase in the respiratory cycle (i.e. the gating window). The aim of this study is to compare the lung dosimetric parameters at RT gated around 40%-60% and 30%-70% windows of a respiratory cycle around end-expiration.

Materials and Methods: Thirty NSCLC patients who underwent four-dimensional computed tomography (4DCT) simulations were studied retrospectively. Patients were CT-scanned under normal respiration. Patients with tumor motion greater than 5 mm were selected for this study. For each patient, two CT datasets were reconstructed (40%-60% and 30%-70% CT gating windows). Planning target volumes, heart, esophagus, and spinal cord were contoured in the 40%-60% and the 30%-70% CT gating window CT data sets. The lungs were contoured separately on both CT data sets. In the lung-contouring process, a Varian Eclipse treatment planning system automatic contouring tool was employed. Default CT threshold values were used. The lung contours were visually verified on each slice. Intensity-modulated radiotherapy plans were generated on the CT data sets with 40%-60% and 30%-70% gating window and doses were recomputed. The evaluation metric was based on dose indices and volume indices for targets and critical structures. Statistical tests were used to establish the significance of the differences between the different gating windows to find the optimal setting of the gating window of a respiratory cycle around end-expiration.

Results: For all patients, homogeneity indices were similar for 30%-70% and 40%-60% IMRT plans. PTV dose uniformity, as indicated by $(D_{95\%}/D_{90\%})$, were all within 0.15 between 40%-60% and 30%-70% gating phases for 13 patients.

The average mean lung dose was 3.1 Gy in the 40%-60% and 30%-70% gating phases. The $V_{10}$ at 40%-60% and 30%-70% gating windows were 4.5% and 4.3%, respectively; The $V_{20}$ at 40%-60% and 30%-70% gating windows were 8.1% and 7.9%, respectively. The $V_{30}$ at 40%-60% and 30%-70% gating windows were 14.3% and 14.5%, respectively. The difference in dosimetric parameters of lung obtained with 40%-60% and 30%-70% gating windows were not statistically different.

The average mean heart dose was 2.2 Gy in the 40%-60% and 30%-70% gating phases. The average mean esophagus dose was 2.4 Gy for 40%-60% plans and 2.5 Gy for 30%-70% plans. The average $D_{95\%}$ cord dose was 10.4 Gy for 40%-60% plans and 10.8 Gy for 30%-70% plans. All the toxicity parameters of the organs at risk did not show any statistically significant correlation in 40%-60% and 30%-70% plans.

Conclusions: We found that lung dosimetric parameters and all the toxicity parameters of the organs at risk were comparable with gating was around 40%-60% or 30%-70% phases. Given that shorter treatment time in the 30%-70% gating windows, it may be more beneficial to deliver the therapy using this parameter.

OC-0255
Protons enable cardiac dose reduction in left sided breast conserving RT even without breath hold
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Purpose/Objective: The use of a breath hold technique enables a significant decrease of the dose to the heart as well as the left anterior descending coronary artery (LAD). Radiation dose to the heart and LAD (i.e. the OARs) could result in long-term cardiac toxicity. A further decrease of the dose to both structures might be possible using proton therapy. We, therefore, examined whether the use of proton therapy (when compared to an IMRT technique) could eventually lead to a further decrease of the dose to the OARs.

Materials and Methods: Twenty patients with left-sided breast cancer referred for radiotherapy after breast conserving surgery were included in our study. All patients underwent a free breathing (FB) and a breath hold (BH) 3D-CT-scan in supine treatment position. CTV and heart and LAD were delineated by one observer.

PTV was composed according institutional guidelines. All plans had to meet the criterion that 97% of PTV was covered by the 95% isodose (95%). The prescribed dose was 42.56 Gy.
For the IMRT technique, forty percent of the dose was given with two open fields, and sixty percent with four inversely planned ‘Step-and-Shoot’ IMRT fields. For proton therapy a spot scanning technique with intensity modulation (IMPT) was used with a three beam set-up. In all plans the gantry angles were 345° (-15°), 27° and 75°. The spots were placed in such way that no spot was more than 0.2 cm outside the PTV and spots separated by 8 mm distance in the plane perpendicular to the beam direction. The spot layers were positioned 5 mm apart from each other.

For both techniques it was attempted to produce the most optimal plan in reducing the dose to the OARs as much as possible. All plans were adapted to the individual target volumes and OARs, using trial-and-error.

We compared IMRT and IMPT based on a FB as well as on a BH CT-scan for all patients.

Results: In all plans coverage of the PTV was adequate. Furthermore, the dose to the OARs was decreased in all IMPT plans compared to IMRT plans. There was only a small difference between BH and FB in the IMRT plans (see the table).

<table>
<thead>
<tr>
<th>Structure</th>
<th>Sørensen-Dice</th>
<th>p-value</th>
<th>Volume (ccm)</th>
<th>p-value</th>
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<tbody>
<tr>
<td>GTV-T</td>
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<td>0.24</td>
<td>0.4</td>
<td>15.5</td>
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<td>GTV-N Standard</td>
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<td>0.16</td>
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<td>GTV-N O-MAR</td>
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<td>0.7</td>
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<td>L. Parotid Standard</td>
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<td>0.07</td>
<td>0.7</td>
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<tr>
<td>L. Parotid O-MAR</td>
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<td>0.09</td>
<td>0.005</td>
<td>19.1</td>
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<tr>
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<td>0.06</td>
<td>0.005</td>
<td>20.5</td>
</tr>
<tr>
<td>BH</td>
<td>1.5</td>
<td>(0.5)</td>
<td>2.7</td>
<td>(1.3)</td>
</tr>
<tr>
<td>IMRT Protons</td>
<td>8.9</td>
<td>(14.4)</td>
<td>31.8</td>
<td>(27.1)</td>
</tr>
<tr>
<td>IMRT Protons</td>
<td>45.9</td>
<td>(0.6)</td>
<td>45.3</td>
<td>(0.8)</td>
</tr>
</tbody>
</table>

Table 1: Mean Sørensen-Dice indexes and mean volumes for delineated structures on standard and O-MAR reconstructions. Standard deviations are shown in brackets.

Conclusions: In this planning study we showed that the use of IMPT results in a dose reduction to almost zero in heart and LAD when compared to IMRT and is associated with adequate target coverage as good as in IMRT. With IMPT a breath-hold technique seems not necessary to reduce the dose in OARs. Since this was a planning study we did not take into account the breathing effects, movement of the patient and their effect on the dose distribution.

OC-0256
Can O-MAR increase precision of delineation in head and neck cancer?
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Purpose/Objective: Delineation of the GTV is a main source of inaccurate in radiotherapy (RT) planning for Head and Neck (HN) cancers partly because precise delineation is often impaired by artefacts from metallic dental implants affecting visualisation of the tumour site and organs at risk (OAR). This study investigates whether the use of the commercially available 'Metal Artifact Reduction for Orthopedic Implants’ (O-MAR) algorithm (Philips Medical Systems) decreases the inter-observer variation of GTV and OAR delineation.

Materials and Methods: CT scans of 11 oropharynx patients prior to curative RT (66-68 Gy/33Fx) were included in this study on basis of streaking artefacts in the tumour area. These 11 patients constitute 20 % of all curative HN patients scanned in this period. Six patients had artefacts evenly distributed bilaterally, 3 had artefacts predominantly on the left side and 2 on the right side. All patients had a GTV-Tumour and 5 also had GTV-Node in proximity to metal artefacts. The OARs closest to dental implants, thus most affected by their artefacts, are the parotid glands.

Three experienced clinical oncologists firstcontoured the GTVs on standard CT reconstructions, without the O-MAR algorithm. Approximately one month later, the GTVs were delineated on the same 11 CT data sets, this time reconstructed with O-MAR. In the same manner, 4 experienced RTTs contoured the parotid glands on both data sets.

To evaluate inter-observer variation, Sørensen-Dice indexes were used to evaluate the statistical significance of the observed differences.

Results: Mean Sørensen-Dice indexes and mean structure volumes are shown in table 1. For all structures, the Sørensen-Dice index was improved on the O-MAR reconstruction. However, this was only statistically significant for the right parotid (p = 0.05).

The volumes of all delineated structures are larger on O-MAR than standard reconstruction. This was statistically significant for GTV-T (p < 0.04), left parotid (p = 0.02) and border line significant for right parotid (p = 0.06).

Conclusions: Delineation of the parotid glands was more precise, and with larger volumes, after reduction of major metal artefacts with O-MAR reconstruction than standard reconstruction. Larger volumes were also observed regarding GTV volumes on O-MAR reconstructed images and consequently larger CTVs and PTVs impacting on dose-planning optimisation.

OC-0257
Delineation of organs-at-risk in the pelvic area: developing guidelines for RTTs
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Purpose/Objective: To test the organ-at-risk (OAR) delineation guidelines developed for RTTs involved in EORTC multicenter clinical trials.

Materials and Methods: CT datasets of 4 patients with pelvic malignancies were used in this ongoing study. The OARs delineated by RTTs from 5 different centers following the guidelines suggested by the EORTC-ROC-RTT group were: the anus, rectum, sigmoid, femoral heads and penile bulb. A software package developed in the NKI-AVL, Amsterdam was used for delineation and assessment of delineation accuracy by measuring standard deviation (SD) of an OAR median structure volume delineated by all observers and then measuring a number of points from each observer’s delineation to the median delineation. If a SD was > 1cm, the guidelines would be considered incomplete and require further refinement.

Results: Results of SD of the median volume for each OAR per patient and its mean are presented in the table below.