Conclusion: PORT for tongue cancer without intraoral stent is best planned with the target volume extending towards the palate to allow for inter-fractional movement of the tongue.

PO-0899
Robustness of fractionated photon RT for pancreatic cancer: Dosimetric effects of anatomical changes
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Purpose or Objective: Anatomical changes taking place over the course of radiation therapy (RT) result in a difference between planned and delivered dose. For pancreatic cancer, we investigated the robustness of clinical treatment plans by quantifying the dosimetric effects of changes in gas volumes, body contour and interfractional target displacement. In addition, we compared the dosimetric effect of anatomical changes between use of bony anatomy and use of intratumoral fiducial markers for patient positioning.

Material and Methods: Nine pancreatic cancer patients were included who had intratumoral markers for daily cone-beam CT (CBCT)-based position verification. The clinical plans (10 MV; 1 arc VMAT; internal CTV (iCTV) to PTV margin = 10 mm) were used for dose calculation. To enable fraction dose calculations on CBCT, the planning CT was deformaedly registered to each CBCT (13-15 CBCTs per patient); air volumes visible on the CBCT were copied to the deformed CT. Calculations were done for marker-based registration (as clinically used) and for bony anatomy-based registration. For both methods, doses were rigidly summed to yield the accumulated doses on the planning CT. For each patient, all DvHs were normalized to yield for the planned dose to the PTV: V98% = 95% (100% = 36 Gy).

To evaluate target coverage, we defined an iCTV+5mm volume, i.e. the iCTV expanded with a 5 mm margin to account for remaining uncertainties including delineation. We analysed D98%, Dmean and D2% for iCTV+5mm and iCTV and examined DVH differences for duodenum and stomach, the organs at risk closest to the iCTV.

Results: For the iCTV+5mm, D98% changed from mean 96.3% (range 95.5–97.8%) for the planned dose to 96.7% (96.4–97.0%) for marker-based accumulated dose (Table 1).

Table 1. Target dose for the 9 patients.

<table>
<thead>
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<th>Planned</th>
<th>Marker-based</th>
<th>Bony-anatomy-based</th>
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<tbody>
<tr>
<td>D98%</td>
<td>96.3</td>
<td>96.7</td>
<td>95.3</td>
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<tr>
<td>Dmean (%)</td>
<td>98.7</td>
<td>99.0</td>
<td>98.8</td>
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<tr>
<td>D2% (%)</td>
<td>100.9</td>
<td>101.2</td>
<td>100.6</td>
</tr>
<tr>
<td>DCTV</td>
<td>96.3</td>
<td>96.7</td>
<td>97.1</td>
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<tr>
<td>Dmean (%)</td>
<td>98.6</td>
<td>99.0</td>
<td>99.0</td>
</tr>
<tr>
<td>D2% (%)</td>
<td>100.7</td>
<td>101.2</td>
<td>100.5</td>
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* Doses <95% in bold.

For each patient, the DvH of the PTV of the planned dose distribution was normalized to D98% = 95%; all other DvHs of planned and accumulated doses were scaled accordingly. For the group, this yielded a PTV D98% of mean 100.8% (range 99.3–104.3%)

These relatively small differences indicate a limited dosimetric effect from changes in gas and body contour, even though the amount of gas visible on CBCT showed large variations (avg. 166 ml, SD 145 ml). In contrast, D98% decreased to 95.3% (85.8–97.9%) for bony anatomy registration, due to systematic errors inherently associated with bony-anatomy patient positioning. Changes for stomach and duodenum depended strongly on the direction of these errors, with large increases in D2% for some (error in direction of organ) and large decreases for others. Differences were largest for the stomach (e.g. D2% from 72.7% (planned) to 82.4% (bony anatomy-based accumulated)). For marker-based positioning, the dosimetric effects for stomach and duodenum were limited (<0.5 Gy in 8 out of 9 patients).

Conclusion: Photon irradiation of pancreatic tumours is robust to variations in body contour and gastrointestinal gas, with dose coverage only mildly affected by these anatomical changes. However, when using bony anatomy for patient positioning, dose coverage declines due to interfractional tumour position variations. Therefore, the use of fiducial marker-based daily position verification is essential in RT for pancreatic cancer.

PO-0900
Dosimetric analysis of organ deformation during prostate IMAT with cone beam CT imaging
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Purpose or Objective: Patients undergoing prostate intensity modulated arc therapy (IMAT) were retrospectively investigated using the CBCT images acquired for setup purposes to determine the volumetric variability of the target and organs at risk and the dosimetric implications of these changes.

Material and Methods: IMAT plans from 11 patients were designed to deliver 74 Gy in 37 fractions to the target. The CTV consisted of the prostate and seminal vesicles, while the PTV was the CTV plus a margin of 10 mm in all directions except posteriorly, where a 5 mm margin was used. For between 9 and 14 of the 37 fractions, the patients were scanned using an on-board CBCT imager to verify the setup. These images were retrospectively registered to the planning CT using an in-house registration algorithm to determine the transformations between the images. The calculated transformation vector field was used to deform the planning CT so that the plan could be recalculated with the original MU on this new adapted CT. This allowed the determination of the dosimetric impact of the change in anatomical information from the time of acquisition of the planning CT to immediately prior to a given treatment fraction. The imaged fractions were treated as though they were representative of the entire treatment and were weighted equally for dose accumulation purposes.

Results: Over the course of the patients’ treatments, the changes in CTV volume compared to the plan were from a decrease of 25% up to a maximum increase of 6%. Their bladder volumes ranged from -10% to 10% of their respective volumes on the planning CT. The rectal volume decreased for all patients, with 5% less than the planning volume the smallest reduction and 34% being the largest volume shrinkage.

The dosimetric impact of these anatomical changes varied for each structure. The minimum dose received by the CTV varied by less than 1% for all patients, with full coverage of the CTV achieved in all fractions. The mean dose delivered to the bladder averaged over each patients treatment resulted in variation of between -4% and 17% of their respective planned mean doses. This did not result in a break of the dose-volume constraints (DVCs) for the bladder at any fraction, for any patient. The rectum received a higher mean dose than the planned value for all patients. This ranged from an increase of 7% up to 38%. It was found that the rectum frequently broke multiple DVCs, resulting in the rectum being overdosed in 79% of the fractions examined.

Conclusion: Analysis of the anatomical condition of the patient on the day of treatment can give an indication of how suitable the original plan for their treatment is. For these patients, although the variability in the anatomy did not

Analysis of the anatomical condition of the patient on the day of treatment can give an indication of how suitable the original plan for their treatment is. For these patients, although the variability in the anatomy did not
result in any significant under-dosing of the target, the observed differences showed that the rectum broke our institutional DVCs during treatment. This is important data required to evaluate the robustness of institutional procedures for the planning and delivery of patients’ treatments.

PO-0901
Investigation of a fast CBCT protocol for supine accelerated whole breast Irradiation
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Purpose or Objective: Acceleration in breast cancer treatment might become the new standard. As fraction dose rises, the importance of correct positioning increases. CBCT is time consuming and uses (low dose) radiation. Increasing interval between positioning and actual treatment reduces precision. We therefore investigated a CBCT technique with lower dose and faster acquisition.

Material and Methods: Both standard and fast pre-treatment CBCT imaging (STAND and FAST) were performed on XVI Elekta ® in a 5-fractions supine whole breast irradiation scheme (5 x 5.7 Gy). The main difference between protocols was gantry speed (Table 1). Central dose was measured with PTW equipment in a CTDI32 phantom. High resolution (HR) and contrast were measured on a CatPhan phantom. Breast contour appearance was assessed on a polystyrene breast phantom. Fifteen clinical CBCT-images for three patients to which FAST or STAND was randomly assigned, were blindly scored by a skilled oncologist. A three-level answer had to be formulated regarding visibility of 1) all clips, 2) entire breast contour, 3) lung/thorax wall edge and 4) excision cavity. Answers were decoded: 0: Not at all; 1: Yes, but only with guidance of reference CT; 2: Yes clearly, without reference CT.

Results: FAST operated at only 53% and 61 % of dose and time of STAND. A low HR (3 lp/mm) was the same for FAST and STAND. Contrast was assessed for STAND through visibility of the largest (15mm) 1% contrast nodule. For FAST, no nodules could be distinguished. There was excess-tissue on cranial and caudal CBCT breast phantom slices, but to the same extent in STAND and FAST. In mid position, breast edge was sharp and coincided with reference CT. The Patient study reflected a difference in the overall low soft tissue contrast for the two protocols. The excision cavity was never scored 2, more 1 for STAND and more 0 for FAST and was less visible with higher breast density (patient 3). Breast contours showed step-wise artifacts near inframammary and axillary folds for both protocols. Lung/thorax wall edges were scored 2 and 1 but the dependency was larger for patient anatomy than for scan protocol. All clips were visible: the rather poor HR is however sufficient. Streak artifacts due to beam hardening and undersampling were apparent in both protocols (Figure 1). Even though the noisy and artifact-rich appearance of the images, effect on clinical decision making for registration is minimal. The stepwise artifacts appear very localized and are easily corrected for in the observer’s mind. Additional information by outer breast contour and lung-thoracic wall edge compensates for this. Distinction between real artifacts and excision cavity can be done by comparison with reference CT. Clips are always visible and of special importance in high density and/or voluminous breasts.

Conclusion: FAST allows the oncologist to register breast CBCT. However, with high density or voluminous breasts, clips are recommended with the use of FAST.

PO-0902
Improving frameless intracranial stereotactic setup with 6DOF couch using two pre-treatment CBCTs
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Purpose or Objective: The primary goal of this study was to evaluate the residual inter-fraction positioning errors of our intra-cranial frameless stereotactic treatment following a six-degree of freedom (6DOF) correction based on automatic bone anatomy matching. A secondary goal was to evaluate the intra-fraction motion.

Material and Methods: Since the implementation of the stereotactic program at our centre, 13 patients were treated with frameless intra-cranial fractionated radiotherapy on a Varian TrueBeam STx linear accelerator. All patients had a planning CT scan with an immobilization system that comprised of a CIVCO head cup, customizable pillow and thermoplastic shell. To guide setup, nose to forehead pitch was calculated using CT information and reproduced at treatment using a digital level. Roll was measured as the difference in height at the level of the anterior ear notch and reproduced at treatment using the in-room lasers. Two pre-treatment CBCTs were acquired; the first to correct using 6DOF bone anatomy matching the initial inter-fraction positioning error and the second to assess the residual inter-fraction error post 6DOF correction. Since our initial experience with the first 3 patients, revealed residual inter-fraction setup errors greater than 1mm, the residual inter-fraction setup error post 6DOF correction was measured and corrected prior each treatment for all remaining 10 patients. Due to the technical limitations of Varian’s 6DOF couch (i.e. maximum 3 degrees pitch and roll), the correction of the residual inter-fraction error was carried out using 4DOF automatic bony anatomy matching (i.e. excluding pitch and roll due to 3degree limitation). A post-treatment CBCT was acquired to determine the intra-fraction motion using 6DOF bone anatomy matching.