Conclusion: Within the limitations of a retrospective study, our results show that the growth and shift of brain metastasis over time can be significant and may vary over patient groups. Given the typical steep dose gradient in SRS treatments (>10%/mm), tumour growths and shifts may have a significant impact on the tumour dose. Therefore, this phenomenon must be considered if the workup and treatment of SRS for brain metastasis is encompassing multiple days.

**OC-0161**

Renal and diaphragmatic interfractional motion in children and adults: is there a difference?


1Academic Medical Center, Department of Radiation Therapy, Amsterdam, The Netherlands

Purpose or Objective: One of the factors determining the size of planning target volume (PTV) margins is organ motion. Organ motion is comprehensively studied in adults and paediatric PTV margins are generally based on these data. We hypothesize that adult-based PTV margins are too large for paediatric patients because children and adults differ in body composition. Our aim was to compare renal and diaphragmatic interfractional motion in children with that in adults and to investigate the correlation with age and height.

Material and Methods: This single-centre retrospective study consisted of 35 children and 35 adults who received thoracic/abdominal irradiation between October 2009 and December 2014. The mean age of children and adults was 10.3 years (range 3.1-17.8 years) and 59.9 years (range 34.1-94.0 years) respectively. Mean height in children and adults was 140 cm (range 92-184 cm) and 175 cm (160-203 cm) respectively. According to protocol, abdominal and/or thoracic Cone Beam CT (CBCT) images were acquired for setup verification before radiation delivery. A total of 70 reference CT (refCT) scans, 350 paediatric CBCTs and 476 adult CBCTs were available for registration using Elekta XVI software. In order to assess renal and diaphragmatic motion, each CBCT was registered to its refCT in 2 steps; registration of: 1) the bony anatomy (i.e., the vertebral column), and 2) the left kidney, right kidney and diaphragm separately. For each individual, we assessed organ motion in the left-right (LR), cranio-caudal (CC), and anterior-posterior (AP) directions for the left and right kidney. Diaphragmatic motion was measured in the CC direction only as a surrogate for upper abdominal organ motion. Subsequently, for all organs the mean and standard deviation of the measurements in all directions were calculated and analysed to estimate the group systematic error (Δ) and the group random error (σ). The correlations between organ motion and age and height were investigated using a univariate regression analysis.

Results: Interfractional organ motion in children and adults was different; displacements in children were notably smaller than in adults. Consequently, the estimated group systematic (Δ) and random errors (σ) for the two groups were different (Table 1). Within each group, no correlation was found between organ motion and age or height. Overall, in the CC direction, weak correlations were found between the patient random error, and age and height (Figure 1).

**Table 1.** The estimated group systematic (Δ) and random error (σ) for children and adults.

<table>
<thead>
<tr>
<th></th>
<th>Children</th>
<th>Adults</th>
</tr>
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<tbody>
<tr>
<td><strong>Right kidney</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>Systematic error (mm)</strong></td>
<td></td>
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<tr>
<td>LR</td>
<td>1.3</td>
<td>1.9</td>
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<tr>
<td>AP</td>
<td>1.6</td>
<td>1.7</td>
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<tr>
<td><strong>Random error (mm)</strong></td>
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<tr>
<td>LR</td>
<td>1.0</td>
<td>1.5</td>
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<tr>
<td>AP</td>
<td>1.7</td>
<td>2.4</td>
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</table>

Conclusions: Our results show that renal and diaphragmatic interfractional motion in children tend to be smaller than in adults, suggesting that abdominal PTV margins in children could be reduced. The difference in organ motion in the two groups could not completely be explained by age or height, indicating that further research is needed to understand the underlying mechanisms.

**OC-0162**

Liquid fiducial markers’ performance in non small cell lung cancer during radiotherapy


1Rigshospitalet, Department of Oncology - Section of Radiotherapy, Copenhagen, Denmark
2University of Copenhagen, Niels Bohr Institute, Copenhagen, Denmark
3Bispebjerg Hospital, Department of Pulmonary Medicine, Copenhagen, Denmark
4Gentofte University Hospital, Department of Pulmonary Medicine, Copenhagen, Denmark
5Rigshospitalet, Centre for Clinical Education, Copenhagen, Denmark
6DTU Nanotech, Department of Micro-and Nanotechnology, Lyngby, Denmark
7Nanovi, Nanovi Radiotherapy A/S, Lyngby, Denmark
8University of Copenhagen, Niels Bohr Institute, Copenhagen, Denmark

Purpose or Objective: We developed a new liquid fiducial marker (BioXmark®) for use in image-guided radiotherapy (IGRT). The liquid solidifies into a three dimensional (3D) structure after injection into tissue. A good level of marker’s
viscosity in a lung phantom using 2D and 3D x-ray imaging was previously shown. We report results and experiences from the study examining the performance (structural - and geometrical stability) of the liquid marker during radiotherapy of patients with non-small cell lung cancer (NSCLC) in free breathing (FB) or deep inspiration breath hold (DIBH).

Material and Methods: Fifteen patients had markers implanted into the primary tumour and/or involved lymph nodes. Cone-beam computed tomography (CBCT) images were acquired daily during the course of radiotherapy (66 Gy / 33 fractions). The fiducial markers were contoured automatically on all the daily acquired images, using a 400 Hounsfield Units (HU) level as threshold, in the treatment planning system Eclipse (v. 13.0), the data was retrieved and analysed using Eclipse scripting API and Matlab v2014b, respectively. The stability of the marker inside the tumour and the lymph nodes was evaluated visually. The structural stability of the marker regarding volume and radio-opacity was evaluated as physical measured volume and mean HU, respectively. The stability of the marker inside the tumour and the lymph nodes was evaluated visually. The structural stability of the marker regarding volume and radio-opacity was evaluated as physical measured volume and mean HU, respectively.

Results: Two patients did not receive radiotherapy and thus 13 patients with 29 markers were analysed (9 injected into tumours and 20 injected into lymph nodes). Ten patients were treated in DIBH and three in FB. All injected markers stayed in the injected site between planning and end of treatment. The variation in global mean HU was larger for all tumours and 20 injected into lymph nodes. Ten patients with 29 markers were analysed (9 injected into tumours and 20 injected into lymph nodes). Fifteen patients had markers implanted into the primary tumour and/or involved lymph nodes. Cone-beam computed tomography (CBCT) images were acquired daily during the course of radiotherapy (66 Gy / 33 fractions). The fiducial markers were contoured automatically on all the daily acquired images, using a 400 Hounsfield Units (HU) level as threshold, in the treatment planning system Eclipse (v. 13.0), the data was retrieved and analysed using Eclipse scripting API and Matlab v2014b, respectively. The stability of the marker inside the tumour and the lymph nodes was evaluated visually. The structural stability of the marker regarding volume and radio-opacity was evaluated as physical measured volume and mean HU, respectively.

In terms of IGRT, the markers were visible on CBCT throughout the treatment; DIBH related artefacts in the markers (due to inter-breath hold variation) were observed on a few patients. Three patients (two DIBH and one FB) showed > 5 mm inter-fraction variation in marker position relative to carina, possibly due to tumour/lymph node shrinkage or anatomical changes. They were all rescanned for treatment adaptation.

Conclusion: The liquid fiducial markers remained stable throughout the treatment course regarding position inside the target, physical volume and radio-opacity on CBCT. The BioXmark® liquid marker offers an interesting alternative to solid markers.

OC-0163
Robustness of proton RT with different beam angles towards inter-fractional motion in the pelvis
A. Andersen1, O. Casares-Magaz2, J. Petersen1, J. Toftegaard1, L. Bentzen1, S. Thörnqvist1, L. Muren1
1Aarhus University Hospital, Medical Physics, Aarhus, Denmark
2Aarhus University Hospital, Radiation Oncology, Aarhus, Denmark
3Haukeland University Hospital, Medical Physics, Bergen, Norway

Purpose or Objective: The benefit of proton therapy may be jeopardized by dose deterioration caused by water equivalent path length (WEPL) variations e.g. due to inter-fractional motion. The aim of this study was to explore patient- and population-specific patterns in the robustness towards inter-fractional motion for pelvic lymph node (LN) irradiation of prostate cancer patients using proton beams from different directions.

Material and Methods: Image data sets of 18 patients consisting of a planning computed tomography (pCT) and multiple repeat CT (rCT) scans with target volumes and organs at risk (ORs) outlined in all scans were used. Ray path WEPLs were computed by averaging over beams eye view WEPL maps at all possible beam angle configurations (for both gantry and couch in 5° angle intervals) considering left and right LNs separately. For 0° couch angle the mean and the standard deviation of the WEPL differences between all rCTs and the pCT WEPL map were extracted for the entire population. Finally, single beam spot scanning proton plans were optimized for all gantry angles (couch angle 0°) over the planning target volume (PTV) generated from the clinical target volume (CTV) using isotropic margin configurations (3 and 5 mm). The optimized fluence maps for the pCT for each beam angle were applied onto all rCTs and the dose distributions re-calculated, and dose differences were extracted.

Results: The WEPL analysis for the left and right section of the lymph nodes showed a general pattern of least variation around couch angle ≈ 0°. Furthermore it showed three minima across the mean of the patient WEPL maps at couch angle ≈ 0° for gantry angles of 0-25°, 125-140° and 170-180° for the left section, as well as gantry angles of 180-220° and 330-355° for the right section, which also appeared to be the angles of lowest variations among patients (Fig.1). The clustering analysis of the WEPL maps at couch angle ≈ 0° against the angles showed for the left section of the lymph nodes that the patients split into three groups from which one group of two patients showed a clearly different pattern of lower variation in the lateral and posterior angles. The other fourteen patients were closer correlated and showed highest variation for the lateral angles (Fig.1). For the right section of the lymph nodes the patients were split into two groups of nine and seven patients, where the seven had a visibly higher variation in the posterior angles as the main difference. The dose calculation results showed similar results as for the WEPL variation, e.g. for the left LNs angles around 25-35°, 100-110° and 160-170° were consistently preferable for the bowel, bladder and rectum as well as LN dose deterioration.

Conclusion: We have found that WEPL maps show population-specific patterns and that there were consistent patterns in which angles are most robust. Similar ‘robust’ angles were also found in the dose/volume analysis.