**PO-0720**

Fiducial based image-guided-intensity modulated radiotherapy (IG-IMRT) in high risk prostate cancer.

G. Eminićz¹, C. Dean², O. Shoffren², P. Wells¹, R. Muirhead¹
¹St. Bartholomew’s Hospital, Radiotherapy Department, London, United Kingdom

**Purpose/Objective:** High dose image guided radiotherapy (IGRT) using prostate fiducials is standard of care for low and intermediate patients. However, high risk patients also benefit from prophylactic intensity modulated radiotherapy (IMRT) to the lymph nodes. The prostate can move independently to the pelvic nodes, therefore the safety of combining fiducial IGRT and pelvic nodal IMRT in high risk patients is uncertain. We aim to ascertain the dosimetric impact of employing fiducial-based hybrid IG-IMRT on the lymph node planning target volume (PTV).

**Materials and Methods:** Thirty consecutive IMRT prostate and pelvic lymph node dosimetric plans were retrospectively reviewed after recalculation with incremental 1mm isocentre movements in all directions up to 10mm. In our centre, all IGRT images and shifts are recorded creating a population based database. Combining this database and the dosimetric data we calculated the overall risk of failing to maintain the following lymph node PTV statistics with fiducial IG-IMRT:

- PTV receiving > 99% of target dose (V99%) > 90%.
- PTV receiving > 95% of target dose (V95%) > 95%.
- PTV receiving > 90% of target dose (V90%) > 100%.

**Results:** Shifts in the left, right, and anterior directions do not have a significant impact on dose delivery with less than 0.25% risk of PTV coverage failure. Shifts posteriorly have the largest impact on dose but this still has less than 1% risk of failing PTV coverage.

**Conclusions:** The risk of failing lymph node PTV coverage is very low with IG-IMRT and therefore we recommend adopting IG-IMRT in high risk prostate cancer patients receiving prophylactic lymph node irradiation. This will allow a reduction in CTV to PTV margins to the prostate volume leading to reduced toxicity and scope for dose escalation.

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**PO-0722**

Planning target volume margins in image-guided radiotherapy (IGRT) for prostate cancer, intra-fraction prostate motion was examined.

Y. Hamamoto¹, H. Inata², Y. Ito², S. Nakayama², Y. Kuribayashi², K. Uwatsu², T. Mochizuki¹
¹Ehime University, Radiology, Ehime, Japan
²Saiseikai Imabari Hospital, Radiology, Ehime, Japan

**Purpose/Objective:** To determine the optimal planning target volume (PTV) margins in image-guided radiotherapy (IGRT) for prostate cancer, intra-fraction prostate motion was examined.

**Materials and Methods:** During 32 fractions of Cyberknife treatment, prostate motion as tracked by the stereoscopic X-ray images of the implanted fiducials was examined. The CyberKnife uses a stereoscopic X-ray system to obtain the position of the prostate target through the monitoring of implanted fiducial markers. If there is a significant deviation, the treatment is paused while the patient is repositioned by moving the couch. The deviations calculated from X-ray images acquired within the time interval between two consecutive couch motions constitute a data set.

**Results:** The averages of intra-fractional motion of fiducial markers were 1.1 mm for cranio-caudal, 0.3 mm for left-right, and 1.2 mm for antero-posterior. The maximum of intra-fractional motion of fiducial markers were 7.9 mm for cranio-caudal, 2.1 mm for left-right, and 11.5 mm for antero-posterior. Intra-fractional fiducial marker motion of 5.0 mm or greater was observed only in two fractions among 32 fractions. In addition, incidence of intra-fractional fiducial marker motion of 3.0 mm or greater increased with time in cranio-caudal and antero-posterior.

**Conclusions:** Although PTV margins of 10 mm or greater is necessary to completely cover the intra-fractional prostate motion, PTV margins of 5 mm were adequate to cover the cranio-caudal and antero-posterior intra-fractional prostate motion in more than 90% of fractions. PTV margins of left-right seemed to be able to reduce to 3 mm. Reduction of treatment time is needed to reduce the PTV margins in IGRT of prostate cancer.

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**PO-0721**

Hypofractionated stereotactic body radiation therapy in localized prostate cancer

H. Kim¹, W.C. Kim¹
¹Inha University Hospital, Radiation Oncology, Inchon, Korea Republic of

**Purpose/Objective:** Technological advanced in stereotactic body radiation therapy have allowed precise targeting and delivery of radiation to the prostate while sparing normal tissues. This is suitable device for performing hypofractionated stereotactic body radiotherapy. We report our experience using cyberknife to patients with localized prostate cancer.

**Materials and Methods:** This study was based on a retrospective analysis of the 65 patients treated with Cyberknife radiotherapy for localized prostate cancer. Image-guided SBRT was delivered to all patients using the CyberKnife (Accuray Inc., Sunnyvale, CA) with motion tracking of internal fiducial seeds. Thirty-five patients identified as low and favorable intermediate risk group received irradiation at a dose of 36.25 Gy in 5 fractions of 7.25 Gy per fraction. Thirty-two unfavorable intermediate and high risk group patients received 45 Gy at whole pelvis by three dimensional radiation therapy or intensity modulated radiation therapy and received a boost by the CyberKnife at dose of 21 Gy in 3 fractions. The acute and late toxicities were recorded using the Radiation Therapy Oncology Group scale and the CTCAE, version 4.0. Prostate-specific antigen response was monitored.

**Results:** All 65 patients finished planned radiation therapy without any severe complication. The median follow-up for patients was 36 months (range 6 - 56 months). There were two biochemical failures in high risk patient who received whole pelvis radiation therapy and cyberknife boost. Acute Grade 1 and Grade 2 gastrointestinal (GI) toxicities were observed in 38.5% and 3.1% of the patients, respectively. There were no acute Grade 3 or 4 GI toxicities. Late Grade 3 GI toxicity, rectal bleeding, was noted in 2 patient in high risk group (3.1%) but bleeding was stopped with 3 times lase coagulation in one patients. Acute Grade 1 and Grade 2 genitourinary (GU) toxicities were seen in 43.1% and 21.5%of the patients, respectively. There was acute Grade 3 urinary frequency in one patients of high risk group.

**Conclusions:** Our results showed favorable biochemical response and low toxicity for hypofractionated stereotactic body radiotherapy with CyberKnife for localized prostate cancer. However, more follow up with a larger cohort is required to confirm durable biochemical control rates and late toxicity profiles.
The relative difference of V40, V60 and V65 between the planned value and the mean value of control plans were \( \Delta V_{40} = 1 \pm 6 \% , \Delta V_{60} = 11 \pm 13 \% , \Delta V_{65} = 31 \pm 33 \% \).

Conclusions: The results indicate that there are variations in balloon position, with a tendency towards increased distance to the isocenter over time compared to the planning CT. This induces V65 and V60 to decrease whereas V40 is rather robust to the balloon shift. We could show that the dose to the rectal wall during treatment was the same or lower compared to the planned dose.

PO-0724
Comparison of volume delineation on simultaneous and standard cone beam CT images during arc radiotherapy (SCART).

S. Mayes1, L. Hamlett2, J. Stratford3, D. Dickinson1, J. Livsey1, A. Attkenhead1
1The Christie NHS Foundation Trust, Clinical Oncology, Manchester, United Kingdom
2The Christie NHS Foundation Trust, Physics, Manchester, United Kingdom
3The Christie NHS Foundation Trust, Radiotherapy, Manchester, United Kingdom

Purpose/Objective: Cone beam computed tomography (CBCT) verification images are typically obtained pre-radiotherapy for step and shoot intensity modulated radiotherapy (IMRT). Volumetric modulated arc therapy (VMAT) allows IMRT to be delivered using single or multiple treatment arcs and CBCT images can be acquired efficiently during treatment as the gantry rotates (simultaneous CBCT, sCBCT). These images are subject to image degradation from megavoltage scatter. The objective of this study is to assess feasibility of reliable organ delineation, and to compare organ position, on sCBCT as compared to CBCT in patients treated for prostate cancer.

Materials and Methods: Five patients had standard CBCT images and sCBCT images taken on fractions 2, 6, 11 and 16 of radical radiotherapy for prostate cancer. Each sCBCT image was corrected to account for MV scatter and improve image quality, yielding 3 datasets per fraction: pre-treatment CBCT, uncorrected sCBCT (usCBCT) and corrected sCBCT (csCBCT). Thus 12 images per patient were available for analysis. Prostate, rectum and bladder volumes were delineated using Pinnacle v9.0 by two observers. The conformity of comparative volumes between each pre-delivery CBCT and corresponding usCBCT and csCBCT was assessed using the Dice Similarity Coefficient (DSC: 1=unity, 0=no overlap of volumes). Mean centroid shift (geometric centre of mass) was calculated to assess gross volume movement.

Results: Results are shown in table 1.

<table>
<thead>
<tr>
<th>Comparison metric</th>
<th>Bladder</th>
<th>Prostate</th>
<th>Rectum</th>
</tr>
</thead>
<tbody>
<tr>
<td>usCBCT Mean (cm)</td>
<td>0.14 (0.03-0.21)</td>
<td>0.76 (0.51-0.92)</td>
<td>0.72 (0.49-0.85)</td>
</tr>
<tr>
<td>usCBCT Mean (cm)</td>
<td>0.17 (0.05-0.30)</td>
<td>0.79 (0.56-0.91)</td>
<td>0.74 (0.52-0.87)</td>
</tr>
<tr>
<td>csCBCT Mean (cm)</td>
<td>0.30</td>
<td>0.55</td>
<td>0.76</td>
</tr>
<tr>
<td>csCBCT Mean (cm)</td>
<td>0.56</td>
<td>0.69</td>
<td>0.69</td>
</tr>
</tbody>
</table>

Table 3: Mean bladder, prostate and rectum DSC values and centroid shifts (cm) for standard CBCT versus uncorrected sCBCT (usCBCT), and standard CBCT versus corrected sCBCT (csCBCT) comparisons.

Conclusions: Mean DSC values indicate a promising degree of conformity between standard CBCT and sCBCT, albeit with relatively large variation in centroid position. This may represent true variation in organ position between acquisition of CBCT and sCBCT, however the data set is small and inter- and intra-observer variability in outlining, in addition to contouring uncertainties due to poorer image quality of sCBCT may explain the disparity. Correction of sCBCT images does not appear to enhance conformity over uncorrected images. Outlining target and organ at risk volumes on sCBCT is feasible, and thus sCBCT acquired have great potential for clinical practice. Using current techniques, the dose to the CTV and organs at risk is calculated using the radiotherapy planning CT. This represents a single point in time and dose predictions will not be completely accurate due to motion and organ motion during course of treatment. sCBCT allows the position of structures to be identified during treatment delivery thereby removing this temporal disconnect and positional uncertainty. Ultimately intra-fraction imaging may allow the dose received by structures to be calculated more accurately and correlated with patient outcome and toxicity, in addition to increasing centre throughput and efficiency. This technique warrants further evaluation.

PO-0725
Variations in thermal parameters at hyperthermia for bladder cancer: A preliminary QA from an ongoing national trial

N. Batta1, E. Puric1, B. Eberle1, N. Lomax1, P. Spoerri2, D. Seiler3, M. Zimmermann1, K. Lehmann1, S. Boddi1
1Kantonsspital Aarau, Radiation Oncology, Aarau, Switzerland
2Kantonsspital, Urology, Otten, Switzerland
3Kantonsspital, Urology, Aarau, Switzerland
4University Hospital, Urology, Zurich, Switzerland
5Kantonsspital, Urology, Baden, Switzerland

Purpose/Objective: Hyperthermia (HT) is part of an ongoing bladder preservation national phase II trial using combined chemoradiotherapy following transurethral resection in T3a,N0,M0 bladder tumours in a national trial. According to the protocol intravesical temperatures between 41.5°C to 42.5°C had to be reached for 60 minutes at the weekly HT sessions delivered by the deep HT unit BSD-2000. The aim of this study was to evaluate quality of heating, monitor specific thermal parameters during the HT sessions and explore the extent of their variability during multiple sessions.

Materials and Methods: Eight patients have been recruited in the protocol so far. A total of 43 HT sessions were delivered. Real time bladder temperatures were monitored using intravesical thermometry during 60 minutes of HT delivery. The thermal parameters evaluated were - minimum, maximum and average temperatures (Tmin, Tmax and Tave) respectively, temperature received by 20%, 50% and 90% of the target (T20%, T50% and T90%) and the mean value of control plans were compared to the planning CT. This represents a single point in time and dose predictions will be not be completely accurate due to motion and organ motion during course of treatment. sCBCT allows the position of structures to be identified during treatment delivery thereby removing this temporal disconnect and positional uncertainty. Ultimately intra-fraction imaging may allow the dose received by structures to be calculated more accurately and correlated with patient outcome and toxicity, in addition to increasing centre throughput and efficiency. This technique warrants further evaluation.

Results: Of the 8 patients, 7 achieved a clinical complete response at completion of treatment. A total of 327 temperature data points were available for the analysis. Details of the measured values are summarized in the Table. Significant variability in the various thermal parameters was not observed, both within the individual patients and across the 8 patients. CEM43T90 was found to have a quadratic relation with the clinical complete response, CET43T90 = 5805.61 - 291.7(Tave) + 3.66(Tave)2 (model r2=0.90,p<0.001) while Tave could be derived from the expression, Tave = -16.2 + 13.3(Tave) + 1.3(CET43T90) - 9.3(Tave), (model r2=0.89,p<0.001).

Conclusions: The various thermal parameters evaluated have not shown significant variability during multiple HT sessions. This could be a consequence of effective phase and amplitude steering feasible with the Sigma Eye HT applicator during these HT sessions. Mathematical models for computation of the key parameters, namely CEM43T90 and Tave were derived, which in future could be used to evaluate their roles as potential predictors of thermotherapy.