PO-1001
Respiratory gating reduces heart doses for proton radiotherapy of the breast and internal mammary chain
S. Hackett1, F. Fiorini1, S. Petillion2, C. Taylor1, C. Weltens2, K. Vallis1, S. Darby1, F. Van den Heuvel1
1University of Oxford, Department of Oncology, Oxford, United Kingdom
2Universitair Ziekenhuis Leuven, Radiotherapie-Oncoologie, Leuven, Belgium
3University of Oxford, Clinical Trial Service Unit, Oxford, United Kingdom

Purpose/Objective: Irradiation of the internal mammary chain (IMC) of lymph nodes may increase local control and overall survival for breast cancer. However, including the IMC in the treatment volume can significantly increase the doses to OARs, so these improvements could be outweighed by increased risk of late toxicities. Doses to cardiopulmonary volumes can be reduced for photon breast radiotherapy, even when IMC nodes are included in the PTV, by delivering treatment only during deep inspiration, but the benefits of respiratory gating for proton radiotherapy have not been examined. This study evaluates the doses to OARs for proton radiotherapy of the breast and IMC during free breathing (FB) and maximum inspiration (MI).

Materials and Methods: Gated and free-breathing CT scans were obtained for 18 patients. The CTVs and PTVs for the IMC and breast, and the OARs (heart, contralateral breast and ipsi- and contra-lateral lung) were outlined. The PTV_{IMC}, excluding the volume overlapping PTV_{Breast}, and PTV_{Breast} were prescribed doses of 40 Gy and 50 Gy respectively.

Treatments were planned with Eclipse v13 for four proton fields ranging from -40° to 75° delivered via spot-scanning. Plans were optimised to minimise doses to the ipsilateral lung and heart whilst ensuring PTV coverage met the constraints that V_{95}\% \geq 95\% and V_{107}\% \leq 2\% of the prescribed dose. The homogeneity index (HI) of CTV coverage was characterised as (D_{98}\% - D_{2}\%)/prescribed dose. Mean doses to the OARs, V_{5Gy} and V_{20Gy} for each lung, and V_{5Gy} and V_{22.5Gy} for the heart were calculated. Dose metrics for CTVs and OARs for plans on paired MI and FB datasets were compared using Student’s t-tests. Doses to CTV_{IMC} were evaluated excluding the volumes overlapped by PTV_{Breast}.

Results: All plans met the criteria for PTV coverage. Metrics for CTVs and OARs are shown in Table 1 and a typical dose distribution, including PTV_{Breast} (red contour) and PTV_{IMC} (blue contour), is shown in Figure 1. The doses to OARs differed significantly between paired plans, with higher doses to the ipsilateral lung but lower doses to the heart for gated compared with free-breathing plans. Homogeneity of CTV coverage also differed significantly, although mean CTV doses did not. The higher HI for CTV_{IMC} than CTV_{Breast} is due to the dose gradient at the border between PTV_{Breast} and CTV_{IMC}.

Conclusions: Proton radiotherapy for breast treatments can achieve highly uniform target coverage whilst delivering low doses to OARs. Gating on the maximum inspiration phase of respiration has the potential to further reduce heart doses whilst slightly increasing doses to the ipsilateral lung. However, the robustness of the dose distributions to respiratory motion and patient positioning errors may also differ between free-breathing and gated treatments, and will be investigated in future work.

PO-1002
Retrospective assessment of treatment planning quality in prostate SBRT
M.R. Malisan1, M. Guerrieri1, C. Foti1, M. Crespi1, E. Moretti1, A. Magli2
1Azienda Ospedaliero Universitaria Udine, Medical Physics, Udine, Italy
2Azienda Ospedaliero Universitaria Udine, Radiation Oncology, Udine, Italy

Purpose/Objective: In prostate SBRT the proximity to PTV of organs at risk represent a formidable challenge in order to ensure the respect of clinical dose constraints. Moreover, there are no objective criteria relative to the degree of conformity or homogeneity of dose in PTV to determine whether an optimal plan has been achieved, so there could be inter-planner differences due to the subjective judgement of plan’s quality. In this study, a dosimetric quality assessment of the first 40 clinical VMAT plans for prostate SBRT is presented with the goal to identify the most efficient quantitative metrics for plan quality evaluation and to improve inter-planner consistency.

Materials and Methods: Since 2012, 40 patients at low/intermediate risk for localized prostate cancer have been planned for SBRT. Fraction size is 6 Gy for 7 fractions,
delivered twice a week with a VMAT technique, with 2 arcs using 6MV photons from a Varian iX linac. Planning was performed by 3 different planners in Varian Eclipse 10.0 TPS with the AAA algorithm. Dose prescription is the average dose to PTV, with the request V95% >95%. Plan quality was assessed using van’t Riet dose conformation number (CN95%), Baltas conformity index (COIN), ICRU-83 homogeneity index (HI), the ratio of the 50% isodose volume to PTV (R50%) to assess intermediate dose spillage, and compliance to protocol constraints. Correlation between each quality index and protocol compliance was performed to identify the most efficient ones.

Results: The main dosimetric results are presented in the following table. For the PTV only the constraint for D95% is not met in 2 cases. As for the OARs, most dosimetric parameters are well within the protocol constraints, with the notable exception of maximal doses to rectum and bladder (D1% less than 95% and 100% of the Prescription dose, respectively) for which the constraints are exceeded in about 20% of cases. Mean and ± s.d. values for CN95%, COIN, R50%, HI are 0.90 ± 0.05, 0.86 ± 0.05, 3.4 ± 0.3, 9.9 ± 2.2%, respectively. CN95% results moreover linearly correlated with both COIN and R50%. It increases with HI and seems to reach a plateau for HI about 11% (see Figure).

Conclusions: Analysis has shown good coverage of PTV and difficulty to meet the constraints relative to the maximal doses of rectum and bladder when these are significantly included in the PTV. As for the measure of plan quality, the average value of CN95% is well above the 0.80 threshold, while its small coefficient of variation suggests a consistent application of the planning protocol among the different planners involved in the study. Due to its correlation with COIN and R50%, CN95% seems the most effective quantitative measure for plan quality in terms of target coverage, dose fall-off and/or general normal tissue sparing. Finally, the best conformity is obtained only with a given degree of dose inhomogeneity in the PTV.

**PO-1003**

Clinical setup accuracy for fractionated stereotactic ablative body radiotherapy for vertebral metastases

C.L. Ong1, J.D. Zindler1, A.C.C. Swinnen1, E.G.C. Troost1, D. Willems1, M. De Rooy1, R.G. Wanders1, P. Lambin1, A. Van Baardwijk1

1MAASTRO clinic, Radiotherapy, Maastricht, The Netherlands

**Purpose/Objective:** Stereotactic Ablative Body Radiotherapy (SABR) for vertebral metastases is an emerging treatment in oligometastatic solid tumor patients to achieve long-term symptom control and sustain quality of life. Accurate patient positioning is essential to avoid radiation-induced myelopathy. In absence of a 6D robotic couch system at the treatment unit, we assessed the inter- and intrafraction setup errors for patients positioned with and without vacuum mattress.

**Materials and Methods:** From November 2013 until July 2014, 9 patients with 10 vertebral metastases were treated consecutively with fractionated SABR (48Gy/24 fractions on the entire affected vertebra with an integrated boost to 66Gy/24 fractions on the metastasis). A dedicated online match with the planning-CT on the spinal canal of the involved vertebra was performed using ConeBeam CTs (CBCTs) prior to every treatment fraction. CBCTs acquired prior to and after treatment were analyzed to respectively evaluate the interfraction pitch and roll setup errors and the intrafraction motions.

**Results:** A total of 411 pre- and post SABR CBCTs were evaluated in 5 patients immobilized using a vacuum mattress and in 4 patients without immobilization device. 4 thoracic, 4 lumbar, and 2 sacral vertebral metastases were treated. No acute grade ≥3 toxicity was observed. For the interfraction setup error analysis, 214 pre-treatment CBCTs were matched offline with planning-CTs to determine the possible pitch and roll. A pitch and roll setup error of ≥2° was observed in 35 fractions (16%). Pitch and roll of ≥2° and ≥3° were less frequent in fractions treated with vs without a vacuum mattress: for ≥2°: 9% vs 26%, and for ≥3°: 2% vs 4%, respectively (p=0.04 chi-square test, Figure 1). The mean ± SD of absolute interfraction pitch and roll values for patients with and without vacuum mattress were 0.90 ± 0.61mm and 0.90 ± 0.82 mm (non-significant, t-test), respectively. For the intrafraction motion analysis, a total of 197 post-treatment CBCTs were evaluated. Intrafraction errors of ≥2mm and ≥2° were less frequent in fractions with vs without a vacuum mattress (1% vs 20%, respectively; p=0.001 chi-square test). Also, intrafraction errors >3mm and >3° were less frequent in fractions treated using vacuum mattress (0% vs 5%, respectively; p=0.001 chi-square test, Figure 1). The mean ± SD of absolute intrafraction motion values for the pelvic bone.

Conclusions: Analysis has shown good coverage of PTV and difficulty to meet the constraints relative to the maximal doses of rectum and bladder when these are significantly included in the PTV. As for the measure of plan quality, the average value of CN95% is well above the 0.80 threshold, while its small coefficient of variation suggests a consistent application of the planning protocol among the different planners involved in the study. Due to its correlation with COIN and R50%, CN95% seems the most effective quantitative measure for plan quality in terms of target coverage, dose fall-off and/or general normal tissue sparing. Finally, the best conformity is obtained only with a given degree of dose inhomogeneity in the PTV.