Electronic Poster: RTT track: Motion management and adaptive strategies

EP-1844 Clinical introduction of simple adaptive radiotherapy for transitional cell bladder carcinoma

N.J.W. Willems[1], P.S. Kroon[1], J.C.J. De Boer[1], G.J. Meijer[1], J.R.N. Van der Voort van Zyp[1], J.L. Noteboom[1]
[1]*UMC Utrecht, radiotherapy, Utrecht, The Netherlands*

Purpose or Objective
Radiotherapy of bladder carcinoma requires substantial CTV-PTV margins to account for day-to-day bladder volume variations. A method to reduce these margins, and hence organs at risk (OAR) dose, is the Plan of the Day method (PotD).
In preparation of a PotD approach, we introduced an offline adaptive radiotherapy (ART) procedure based on ConeBeam CT (CBCT) analysis to select individualized adequate margins for the bladder. Tight PTV margins were defined on a retrospective CBCT analysis (N=9, 56 CBCTs) (table 1).

PTV bladder margin (mm)	cranial	caudal	ventral	dorsal	right	left
wide	15	10	15	15	10	10
tight	10	6	10	10	6	6

Table 1: CTV-PTV margins for initial plan (wide) and adaptive (ART) plan (tight)

Material and Methods
Pretreatment MRI scans with variable bladder filling were acquired to determine the GTV and the empty, medium and fully filled bladder structure (CTV). During the pretreatment CT planning the bladder was filled according to the medium filled MRI protocol (± 200 mL). All patients were treated with a Volumetric Modulated Arc Therapy (VMAT) Simultaneous Integrated Boost (SIB) technique. The prescribed dose was 46 Gy (2 Gy per fraction) to the bladder and 59.8 Gy (2.6 Gy per fraction) to the GTV.
Patients were instructed to perform a comfortably filled (± 200 mL) bladder during treatment. Before each treatment session a CBCT was obtained and a manual soft tissue match was performed on the bladder volume. When the PTV did not cover the bladder volume correctly, patients were asked to void their bladder or drink water. The GTV location was decisive for the match. A subsequent 3D online translation correction was applied. The initial 3 treatment fractions were delivered with a plan based on the medium filled bladder with wide PTV margins (table 1). After 3 fractions it was decided if an ART plan could be used. The best fitting CTV (empty, medium or full) (figure 1) and PTV (wide or tight) margins were chosen. The ART plan was delivered from fraction 6 to 23. Daily online CBCT position verification was still performed to monitor adequate bladder coverage by the PTV.

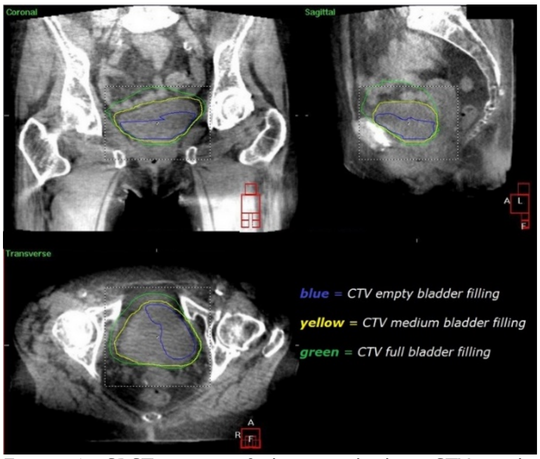

Figure 1: CBCT image of the initial plan. CTV medium bladder filling fits well on CBCT bladder.

Results
5 patients were treated with our simple ART method since June 2016. For 3 patients the medium bladder filling with tight PTV margins were used. The mean PTV was 28% smaller for the adaptive plans compared to the initial plans.
The other 2 patients were treated with a medium bladder filling and wide PTV margins during the whole treatment. One of these patients could, in retrospect, have been treated with tight margins because the bladder filling became smaller after fraction 3. The other patient showed deformation of the bladder, and the treatment had to be continued with wide PTV margins.

Conclusion
A simple ART workflow was introduced for bladder carcinoma. By offline selection of a plan based on the most representative treatment bladder volume, tight PTV margins could be applied and OAR doses were thus reduced. Daily verification of the bladder filling is necessary to monitor the GTV and CTV coverage. This approach to ART in bladder carcinoma is a safe and simple method to reduce PTV margins.

EP-1845 The impact of intra-fractional bladder filling on adaptive bladder radiotherapy

A. Krishnan[1], Y. Tsang[1], A. Stewart-Lord[2]
[1]*Mount Vernon Cancer Centre, Radiotherapy Department, Northwood, United Kingdom*
[2]*London South Bank University, School of Health & Social Care, London, United Kingdom*

Purpose or Objective
To assess the effect of intra-fractional bladder filling on adaptive bladder radiotherapy and investigate if the current departmental adaptive bladder treatment planning margins and plan selection options are appropriate.

Material and Methods
A retrospective audit was carried out on 38 pairs of pre-treatment and post-treatment cone beam computed tomography scans (CBCTs) from 20 adaptive bladder radiotherapy patients. The bladder was contoured on both pre and post-treatment CBCTs to quantitatively analyse the differences in bladder volume and bladder wall expansion over the treatment fraction. Treatment time was established from acquisition of pre-treatment CBCT to acquisition of post-treatment CBCT. A non-parametric Spearman's Rank correlation test was conducted to investigate if there was a relationship between intra-fractional bladder filling and treatment time.

Results
A variety of intra-fractional bladder filling and intra-fractional bladder wall expansions were observed. Mean

intra-fractional filling volume was 10.2cm^3 (standard deviation (SD) = 7.1cm^3; range= 0.3-26.9cm^3). Average treatment time was 8.9 minutes (SD = 1.8mins; range= 6.5-13.6mins). Intra-fractional bladder filling resulted in expansion of the bladder predominately in the superior and anterior directions with mean translations 2.5mm (SD=1.9mm; range= 0-6mm) and 1.5mm (SD=1.4mm; range= 0-5mm) respectively.
As expected, an increase intra-fractional bladder filling was associated with an increase overall treatment time (r_s = 0.323, p = 0.048). All plan selection options chosen adequately covered the bladder target treatment volume.
Conclusion
Despite the effect of intra-fractional bladder filling, it's suggested that current use of the adaptive bladder treatment planning margins and decision making for all plan selections sufficed. All treatments were delivered within an appropriate time frame for the local hospital department. Due to the limited expansion of the bladder wall laterally, consider reducing the lateral margin requirement if a more conformal plan could be selected whilst minimising dose to the surrounding normal tissue.

EP-1846 Verification of latency in respiratory gating with proton beam therapy
I. Maeshima[1]
[1]*aizawa hospital, proton center, Matsumoto, Japan*

Purpose or Objective
Gating function has been available in our hospital for the proton therapy system since March, 2016. Gating signals generated by a respiratory gating system control the output of proton beam. However, there is latency between gating control signal and proton beam emission/interception and a long latency would affect the treatment accuracy. We verified the latency periods and report the results here.
Material and Methods
A globally used respiratory gating system Abches was used for gating signal control. A motion phantom was used for respiratory motion simulation with two modes of motion phantom respiratory speed: 3 sec/fraction and 6 sec/fraction. Gating function was enabled by the Wobbler method in the proton therapy system. The latency between the start of gating signal emission and the start of proton beam generation, and that between the end of gating signal emission and the interception of the proton beam were measured.
Results
With the motion speed at 3 sec/fraction, the mean latency at the start of signal emission was 61.75±20.55 msec and at the end of gating signal was 41.4 ± 30.69 msec. With the motion speed at 6 sec/fraction, the mean latency at the start of signal emission was 36.7±27.24 msec and at the end of gating signal was 46.8±28.73 msec.)
Conclusion
The results of gating latency between our proton therapy system and the respiratory gating system Abches in this study satisfied the AAPM-TG142 recommended criteria of 100 msec, proving the applicability of the systems.

EP-1847 Inter-fraction motion of the uterine cervix during EBRT measured using CBCT and polymer markers
F. Nijeboer[1], A. Snyers[1], L. Verhoef[1], T. Branje[2], R. Van Leeuwen[1]
[1]*Radboudumc, Radiation Oncology, Nijmegen, The Netherlands*
[2]*Fontys University of Applied Sciences, MBRT, Eindhoven, The Netherlands*

Purpose or Objective
In external beam radiotherapy of the uterine cervix, large day-to-day movements of the cervix can be seen that are associated with changes in rectum and bladder filling. These movements should be taken into account in treatment planning, by delineation of an internal target volume (ITV), a careful choice of safety margins, or daily plan selection based on the position of the uterus. In this study, the motion of the uterine cervix was monitored using implanted polymer markers visualized by CBCT. The correlation of this motion to bladder and rectum filling was estimated, and treatment margins were calculated.
Material and Methods
234 CBCT images of 10 patients with implanted markers were included. Interfraction motion of the cervix was studied by determining the 3D vector between the center of the markers on CBCT and (full-bladder) planning CT. An inter-observer variability study was determined for this analysis. The correlation between cervix and bladder dimensions and rectum diameter was studied. CTV-PTV margins were calculated using the Van Herk recipe.
Results
A strong and statistically significant correlation of cervix motion in the AP direction was found with the rectum diameter (Pearson correlation coefficient r = 0.82 (p < 0.001)). Correlation with the bladder dimensions in this study was found significant however weak for the AP and SI directions (-0.29 and -0.28 (p < 0.001), respectively). Motion of the cervix was largest in the AP and SI directions (Mean (SD of means): 4.1 (11.5) and 5.0 (5.6), respectively) The calculated margins equal 8.7, 33.0 and 18.0 mm in the LR/AP/SI directions.
Conclusion
Correlation with bladder and rectum filling, and preferred direction of motion, were shown comparable to previous studies. Calculated CTV-PTV margins were larger than those used in clinical practice. These can be decreased when an ITV is delineated based on multiple CT/MR images with varying bladder/rectum filling, or when a plan-of-the-day approach is used.

EP-1848 Dosimetric evaluation of CBCT data in adaptive PoD for cervix cancer
K. Bath[1], D. Vignarajah[2], M. Marban[3], T. Hague[1], A. Baker[4], Y. Tsang[4], P. Hoskin[2]
[1]*Mount Vernon Cancer Centre, Radiotherapy Physics, London, United Kingdom*
[2]*Mount Vernon Cancer Centre, Oncology, London, United Kingdom*
[3]*Hospital Universitario Doctor Negrín, Radiation Oncology, Palmas de Gran Canaria, Spain*
[4]*Mount Vernon Cancer Centre, Radiotherapy, London, United Kingdom*

Purpose or Objective
Adaptive plan of the day (PoD) for cervical cancer has recently been implemented at our centre. PoD using daily CBCT reduces the risk of geometric miss by actively choosing a suitable plan based on a variable CTV position and has the potential of reducing toxicity to organs at risk (OARs). This planning study aimed to assess the potential benefits by recalculating the plan on the daily CBCT datasets, comparing changes to CTV and OAR dose as treatment progressed.
Material and Methods
All patients treated with this technique had planning CTs acquired with empty and full bladder and a MRI with mid-bladder filling. Multiple CTVs were outlined on each of the datasets to include uterus and proximal vagina, from which ITVs and PTVs were defined with further nodal volumes as required. VMAT plans were created for each PTV. Online daily CBCT was performed for all patients over the course of 25 treatments and the appropriate PoD was chosen based on the position of the CTV.
The cervix CTV, rectum, bladder and bowel organs were contoured on all CBCTs. Initially the chosen PoD treatment