Organ sparing potential and intra-fraction robustness of IMPT for cervical cancer

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PURPOSE
Chemoradiation (CHRT) for cervical cancer results in severe chronic and acute toxicity, and acute hematologic toxicity causing CHRT discontinuation. IMPT may reduce OAR dose, however inter- and intra-fraction variability may affect target coverage. While inter-fraction variability can be addressed by adaptive replanning strategies, robustness against intra-fraction variability should be maintained. Our aim was to report on the potential of IMPT to reduce OAR dose and to study target coverage robustness of IMPT compared to VMAT versus intra-fraction motion.

MATERIALS & METHODS
Pre-fraction and post-fraction repeated CTs with time interval of 10 minutes (preCTs and postCTs) from 5 cervical cancer patients were available, for whom target volumes included the para-aortic region. Two-field PBS-PT (2F), four-field PBS-PT (4F) and two-arc VMAT primary treatment plans were robustly planned and evaluated with ITV prescription dose 45 Gy (see for example figure 1). Each reCT was contourd and registered to the planCT and subsequently, all 3 plans were recomputed on each reCT. OAR doses and pre-post intra-fraction dose differences delivered to 98% of the GTV and ITV (GTV, uterus, vagina and nodes + margin) vs intra-fraction bladder volume differences were analyzed.

RESULTS
Mean bowel bag dose was reduced by nearly a half (Figure 1A), mean bone marrow dose decreased significantly (Figure 1B) and also all other OAR doses were lower (Table 1) for both IMPT plan types compared to VMAT. IMPT showed similar target coverage robustness as VMAT against all intra-fraction bladder volume changes (Figure 2).

CONCLUSION
Robustly optimized PBS-PT treatment plans for cervical cancer patients show equivalent robustness against intra-fraction variability when compared to VMAT treatment plans, but offer significantly better OAR sparing.

Table 1 – Average OAR dose ± average intra-fraction dose deviation on all 10 reCTs

<table>
<thead>
<tr>
<th>OAR parameter</th>
<th>VMAT</th>
<th>PBS-PT 2F</th>
<th>PBS-PT 4F</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔV95% bone marrow (%)</td>
<td>89.4 ± 0.6</td>
<td>65.9 ± 0.9</td>
<td>63.8 ± 0.6</td>
</tr>
<tr>
<td>ΔV95% bone marrow</td>
<td>66.6 ± 0.9</td>
<td>55.4 ± 0.9</td>
<td>41.4 ± 0.2</td>
</tr>
<tr>
<td>Dmax femoral head (GyRBE)</td>
<td>21.4 ± 0.0</td>
<td>6.0 ± 0.0</td>
<td>8.4 ± 0.0</td>
</tr>
<tr>
<td>Dmax sacrum (GyRBE)</td>
<td>36.3 ± 0.2</td>
<td>36.0 ± 0.1</td>
<td>33.3 ± 0.1</td>
</tr>
<tr>
<td>Dmin sacrum (GyRBE)</td>
<td>36.0 ± 0.2</td>
<td>36.0 ± 0.1</td>
<td>33.9 ± 0.1</td>
</tr>
<tr>
<td>V95% bowel bag (%)</td>
<td>52.4 ± 0.5</td>
<td>24.9 ± 1.7</td>
<td>28.3 ± 1.3</td>
</tr>
</tbody>
</table>

Figure 1 – OAR DVH comparison. A: Bowel bag relative volume (%) vs received dose (GyRBE) and B: Bone marrow relative volume (%) vs received dose (GyRBE). The solid lines in graph A and B display the mean dose for the pre- and postCTs, the error bars display the 95% confidence interval.

Figure 2 – D98% GTV and D98% ITV (GyRBE) difference between pre- and postCT for each patient. The bladder volume difference between the pre- and postCT is displayed in cc.

References: