Introduction and aim

Tumor motion in stereotactic body radiotherapy (SBRT):
• Succes of SBRT is limited by tumor motion
• Many strategies exist to mitigate the dosimetric impact of motion

Aim: Compare four motion adaptation strategies for liver SBRT:
• Respiratory gating
• MLC tracking
• Baseline drift correction by inter-field couch shifts
• No intrafraction motion adaptation

Methods

Patients:
• Fifteen liver SBRT patients previously treated with Calypso electromagnetic guided respiratory gating in three fractions [1]

Treatment planning:
• 5 mm (axial) and 7-10 mm (cranio-caudal) CTV-to-PTV margins
• Conformal or IMRT plans with seven fields
• Targets covered with 67% (PTV) and 95% (CTV) isodoses

Investigated motion adaptation strategies:
• Calypso-guided respiratory gating in exhale (actual treatment)
• Calypso-guided MLC tracking (simulation)
• Couch correction before each treatment field if the mean position error during the previous field exceeded 2mm (simulation)
• No intrafraction motion adaptation, i.e. only daily adaptation to the mean tumor position by a setup CBCT scan (simulation)

Dosimetric evaluation:
• Dose reconstruction with calculation of motion-induced reduction in CTV D95 relative to the planned dose ($\Delta D_{95}$)

Table 1. Mean (and range) number of couch corrections and reduction in delivered CTV D95 with 7mm and 10mm cranio-caudal PTV margins.

<table>
<thead>
<tr>
<th></th>
<th>Gating</th>
<th>MLC tracking</th>
<th>Baseline drift correction</th>
<th>No motion adaptation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of couch corrections</td>
<td>2.8 (0 - 7)</td>
<td>0</td>
<td>1.4 (0 - 5)</td>
<td>0</td>
</tr>
<tr>
<td>$\Delta D_{95}$ with 7 mm CC margin (%-point)</td>
<td>0.8 (0.1 - 1.8)</td>
<td>1.0 (0.3 - 2.2)</td>
<td>4.0 (0.4 - 13.3)</td>
<td>8.1 (0.6 - 29.4)</td>
</tr>
<tr>
<td>$\Delta D_{95}$ with 10 mm CC margin (%-point)</td>
<td>-</td>
<td>-</td>
<td>2.9 (0.2 - 9.8)</td>
<td>4.8 (0.3 - 14.8)</td>
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</table>

Figure 1. Planned dose distribution with 7 mm CC margin shown in a coronal plane through the CTV (red) and PTV (blue), and reconstructed dose distributions for the four motion adaptation strategies accumulated over all three fractions for Patient 1. Dose levels ≥95% are shown.

Figure 2. Mean reduction in delivered CTV D95 dose relative to the planned course dose per patient for all motion adaptation strategies.

Figure 3. Mean CTV dose volume histogram of all treatment fractions. Shaded areas show the 10th-90th percentile range.

Conclusions

• Four motion adaptation strategies were compared for liver SBRT
• Inter-field couch correction can mitigate gross dose errors without the requirement of real-time motion monitoring.
• Gating and MLC tracking were much more effective strategies that ensured high similarity between planned and delivered doses
• Gating was slightly better than MLC tracking dosimetrically, but required several couch corrections and had lower duty cycle

Results

• Table 1 summarizes the number of couch corrections to compensate for tumor drift as well as the CTV $\Delta D_{95}$ of the four strategies with 7mm and 10mm cranio-caudal PTV margins.
• For three patients, systematic cranial tumor drift resulted in a mismatch between the tumor and high dose volume without intrafraction motion adaptation (Figures 1-2)
• The dose was partly restored with inter-field couch corrections and fully restored with gating and MLC tracking (Figures 1-3)

Acknowledgements

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References