Daily IGRT with CT-on-Rails Can Safely Reduce Planning Margin for Prostate Cancer: Implication for SBRT

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Why Margin?

- Without correction: prostate may move 5.3-9.2, 7.0-14.6 and 8.7-11.0 mm in the left-right, sup-inf and ant-posterior dimensions (Button et al., Clinical Oncology 2010)

- Margin increases confidence of dose coverage for target
Technology pushes margin reduction

- Tumor control + Min. Side Effect = Better life quality
- Feasibility of margin reduction should be examined with improved patient setup techniques

Internal anatomy image verification, i.e., bone, soft-tissue, implanted marker

External apparatus, i.e., skin tattoo, vacuum bags, endorectal balloon
Compared with CBCT, CT-on-rails images show more consistent and accurate registration with the planning CT.
Objective

➢ To investigate the potential of margin reduction with daily IGRT for prostate cancer using CT-on-rails

➢ To evaluate the dosimetric benefit of margin reduction for organs at risk (OAR)
Method

- Daily CT of the first seven (n = 63) and last seven (n = 63) TX fractions from nine patients w/ prostate cancer

- Four planning margin sizes:
  - 8mm everywhere except for 5mm posteriorly, a.k.a., 8mm/5mm
  - 6mm/4mm posterior; 4mm/2mm posterior; 2mm uniform

- Daily dose calculated with beam isocenter shifted according to the clinical IGRT
Method

- Prostate and OAR (rectum and bladder) were contoured for each daily CT by the same physician for the planning CT.

- Daily dose distribution evaluated using:
  - $V_{100}$ and $D_{99}$ for prostate, target coverage
  - $V_{65Gy}$ for bladder and $V_{70Gy}$ for rectum, OAR sparing
Results – Daily target volume change

- Prostate vol. changes were relatively small (Average: $1.3\% \pm 6.0\%$, range: $-14.9\%$ to $16.0\%$)
- $5\sim 10\%$ of volume change may be attributed to intra-observer variance (Peng et al., 2011 Intl J Radiat Oncol Biol Phys)
Results – Daily OAR volume change

- Bladder & Rectum had large volume changes despite of pre-treatment instructions of full bladder and empty rectum.

- The prostate deformation and rotation from these volume changes cannot be fully corrected by current IGRT and thus planning margin is required.
## Results – Daily prostate coverage

<table>
<thead>
<tr>
<th>Planning Margin (mm)</th>
<th>8 / 5 Posterior</th>
<th>6 / 4 Posterior</th>
<th>4 / 2 Posterior</th>
<th>2 uniform</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>D_{99} (%)</strong></td>
<td></td>
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<tr>
<td>First 7 Days</td>
<td>100.0±2.5</td>
<td>99.8±2.7</td>
<td>98.7±4.6*†</td>
<td>94.9±9.9*</td>
</tr>
<tr>
<td>Last 7 Days</td>
<td>99.4±3.6</td>
<td>99.2±2.4</td>
<td>93.3±9.6*</td>
<td>91.9±8.7*</td>
</tr>
<tr>
<td><strong>V_{100} (%)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>First 7 Days</td>
<td>99.1±1.6</td>
<td>98.9±1.8</td>
<td>97.0±4.2*†</td>
<td>93.2±7.1*†</td>
</tr>
<tr>
<td>Last 7 Days</td>
<td>98.9±1.6</td>
<td>98.3±2.0*</td>
<td>94.8±5.0*</td>
<td>90.5±7.6*</td>
</tr>
</tbody>
</table>

- * P < 0.05 compared with the margin of 8mm/5mm posterior.
- † P < 0.05 compared with the last 7 treatment days
Results – Daily prostate coverage

With 4/2 mm and 2 mm uniform margins, 68% and 44% of daily fractions showed $V_{100} > 95\%$, respectively.

96% of daily fractions showed $V_{100} > 95\%$ with 8/5 mm & 6/4 mm margins.
Results – Daily bladder dose

- Every step of margin reduction decreased $V_{65Gy}$ ($p<0.05$)
- Daily bladder dose was within RTOG 0126 constraint ($V_{65Gy} < 50\%$) for all fractions even for 8/5 mm margin
Results – Daily rectum dose

- Every step of margin reduction decreased $V_{70Gy}$ ($p<0.05$)
- Rectum dose higher than RTOG 0126 constraint ($V_{70Gy}<20\%$) in a few fractions (11% for 8/5 mm; 6% for 6/4 mm; 1% for 4/2 mm and 2 mm)
Discussion & Conclusion

- Reduction of margin size to 6mm/4mm posterior is safe and offers better OAR sparing (consistent with the recommended 5 mm margin in Godley et al., 2012)

- If margins of 4mm/2mm posterior or less is really desired:
  - More accurate registration (maybe) ??
  - 6-D couch
  - Daily dose monitoring (Li et al., Med Phys, Accepted in Oct. 2013)
Implications for SBRT

• With CT-on-rails replacing CBCT, margin reduction should be also feasible for SBRT

• The extent of margin reduction needs be re-examined as it depends on:
  - the external patient set up techniques, i.e., endorectal balloon
  - the level of inter-fractional variations
Thank you for your attention!