Evaluation of the TomoTherapy Planning Station Heterogeneity Correction Algorithm Using an Anthropomorphic Phantom

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Introduction

• Previous studies of lung density corrections
  – based on slab phantoms
  – simple beam geometries

• Current generation convolution based algorithms should provide better dose estimates

• Limited data is available verifying the accuracy of treatment planning systems in an anthropomorphic phantom

• Differences between implementations of heterogeneity correction algorithms needs to be quantified before applying them in multi-institutional clinical trials
Objectives

- Evaluate the TomoTherapy Planning Station’s heterogeneity dose calculation algorithm using the RPC’s anthropomorphic lung phantom.
  - Develop a clinically conformal treatment plan for the lung insert with a centrally located tumor.
  - Measure delivered doses by these treatments using TLD and radiochromic film.
  - Compare measured and calculated dose distributions based on the TG-53 criteria of $\pm5\%/5\text{mm}$. 

• RPC’s Anthropomorphic Thorax Phantom
  – Simulated heart, spine, lungs, and lung tumor heterogeneities
  – Tumor located centrally
  – TLD (Tumor, Heart, Cord)
  – Radiochromic film (Axial, Coronal, and Sagittal)
# Doses per MV CT

<table>
<thead>
<tr>
<th>MV CT Irradiation</th>
<th>PTV Sup (cGy)</th>
<th>PTV inf (cGy)</th>
<th>Cord (cGy)</th>
<th>Heart (cGy)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>1.23</td>
<td>0.98</td>
<td>1.05</td>
<td>1.08</td>
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<tr>
<td>2</td>
<td>1.00</td>
<td>1.01</td>
<td>1.11</td>
<td>1.05</td>
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<td>3</td>
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<td>1.00</td>
<td>1.14</td>
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<tr>
<td>average</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>std dev</td>
<td>0.07</td>
<td></td>
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</tr>
</tbody>
</table>
Methods and Materials

- Conformal Treatment Plans
  - Clinically constrained prescriptions
  - Helical delivery with 2.5 cm field length
  - 6 MV
  - 10 Gy to prescription point
# TLD Results
(Doses in Gy)

<table>
<thead>
<tr>
<th>Irradiation</th>
<th>PTV Sup</th>
<th>PTV inf</th>
<th>Cord</th>
<th>Heart</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>9.85</td>
<td>9.93</td>
<td>1.11</td>
<td>1.35</td>
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<tr>
<td>2</td>
<td>10.06</td>
<td>9.93</td>
<td>1.07</td>
<td>1.30</td>
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<tr>
<td>3</td>
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<td>10.00</td>
<td>1.05</td>
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<td>4</td>
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<td>1.06</td>
<td>1.27</td>
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<tr>
<td>average</td>
<td>9.90</td>
<td></td>
<td>1.07</td>
<td>1.30</td>
</tr>
<tr>
<td>std dev</td>
<td>0.08</td>
<td></td>
<td>0.03</td>
<td>0.03</td>
</tr>
<tr>
<td>Meas./Calc.</td>
<td>0.99</td>
<td></td>
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</tr>
</tbody>
</table>
With fiducials marking the center of the target
Conclusions

1. Patient doses form the MV CT are negligible compared to the total prescription dose delivered.

2. The TomoTherapy Planning Station heterogeneity correction algorithm calculates the tumor dose correctly in the presence of a lung heterogeneity.

3. Caution is warranted in the setup of patients using the MV CT, especially for symmetric tumors.