Influence of Patient Setup and Target Delineation on Air Cavity Tomotherapy Dosimetry

J. Lian, D. Fried, M. Lehman-Davis, S. Chang, B. Chera
Department of Radiation Oncology, The University of North Carolina at Chapel Hill, NC

**Purpose**

- Large air cavity is commonly seen in the radiation therapy treatment planning of head and neck cancer.
- The aims of this study are:
  1. Determine if three different methods of PTV delineation at an air cavity interface yield differences in overall tomotherapy plan quality and treatment efficiency, and
  2. Analyze how patient setup uncertainty affects the delivered dose for these three target definitions.

**Methods**

- **PTV definitions**: Four patients of maxilla sinus or oral cavity were studied. Three PTVs for each patient were contoured around a CTV surrounded by a large air cavity. The CTV lined the surface of the air cavity while PTV1 included the entire air cavity, PTV2 extended 4 mm from the surface of the cavity into air, and PTV3 was reduced 4 mm within the surface of the cavity (Figure 1).
- **Treatment planning**: Tomotherapy plans were made for these PTVs with the same dosimetric constraints and optimization parameters.
- **Setup uncertainty simulation**: For each PTV based plan, patient CT was shifted 5 mm in anterior, left and superior direction, respectively. The original beamlets of non-shifted plan were recomputed using tomotherapy DQA software on three shifted CTs, which simulated the non-ideal patient setup.
- **Dosimetry analysis**: 48 treatment plans, to account for the combination of target definitions and patient shifts, were generated for comparing the dosimetric endpoints including DVH, maximum and mean dose.

**Results**

![Figure 2. Isodose of plans of a selected patient using three types of PTV definition.](image)

A) PTV1, B) PTV2 and C) PTV3 were used as optimization target, respectively. The resulting plans not only had similar CTV coverage but also the similar sparing of normal tissue and comparable treatment times (see Table 1).

<table>
<thead>
<tr>
<th>Target used in planning</th>
<th>Skin max (cGy)</th>
<th>Optic nerves max (cGy)</th>
<th>Brainstem max (cGy)</th>
<th>Spinal cord max (cGy)</th>
<th>Parotids mean (cGy)</th>
<th>Cochleas mean (cGy)</th>
<th>Treatment times (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planned to PTV1</td>
<td>6337</td>
<td>4616</td>
<td>3818</td>
<td>3140</td>
<td>1515</td>
<td>3511</td>
<td>4.8</td>
</tr>
<tr>
<td>Planned to PTV2</td>
<td>6345</td>
<td>4615</td>
<td>3837</td>
<td>3104</td>
<td>1535</td>
<td>3415</td>
<td>4.6</td>
</tr>
<tr>
<td>Planned to PTV3</td>
<td>6253</td>
<td>4597</td>
<td>3866</td>
<td>3041</td>
<td>1513</td>
<td>3429</td>
<td>4.6</td>
</tr>
</tbody>
</table>

**Table 1. Dose to normal tissues and treatment times.** All plans attained 95% coverage of the CTV and respective PTV used in planning by 100% of the prescription.

**Conclusions**

There was no significant difference of dosimetric quality and treatment efficiency of tomotherapy plans with three different ways of including the air cavity in PTV. However, the target coverage of PTV2 definition was more vulnerable to patient setup uncertainty. PTV1 and PTV3 definition had overall comparable robustness of delivery and each was more resistant to setup error on certain structures.

---

**Figure 1. Three types of PTV definition.** The black line is the common portion of all anatomic structures. PTV1, PTV2, and PTV3 are represented by a combination of the black line plus the blue, green, and yellow lines, respectively. The CTV is represented by the black line plus the red line.