Practical Implementation of Deep Inspiration Breath Hold Techniques for Breast Radiation Therapy

Session Introduction

- DIBH was discussed >10 years ago in the AAPM Task Group 76 report but is still not the standard of care in many clinics, which may be partially because of challenges associated with its implementation.

- Therefore, this session will focus on how to clinically implement four DIBH techniques:
  1. Active breathing control (Daria Comsa, PhD)
  2. Spirometric motion management (Scott Hadley, PhD)
  3. 3D surface image-guided (X. Lily Tang, PhD)
  4. Self-held breath control with respiratory monitoring and feedback guidance (Kent Gifford, PhD)

Dosimetric Benefits of DIBH for Breast Radiation Therapy

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Deep Inspiration Breath Hold (DIBH)

- Patient is simulated and treated during the deep inspiration phase of the breathing cycle.

**Anatomic changes:**
- Air is drawn into the thoracic cavity
- Diaphragm contracts and descends
- Abdomen is forced inferiorly and anteriorly
- Intercostal muscles contract
  - Ribs are pulled superiorly and anteriorly
  - Thorax diameter is increased anteriorly and laterally

Deep Inspiration Breath Hold (DIBH) Fig. 3, TG76 (2006)

Anatomic Changes During DIBH - Heart

- Registered images from CT scans in DIBH [grayscale] and free-breathing (FB) [orange] modes.

**Heart displaced posteriorly, inferiorly, and to the right.**

Anatomic Changes During DIBH - Heart

- Heart displacement during DIBH results in less heart volume included in breast radiation fields.

**How much less? &gt; 1 cm**

- Comsa et al. (2014) reported maximum linear distances of heart within tangential breast fields was 1.6 cm for FB and 0.4 cm for DIBH.
• Numerous studies have demonstrated a decrease in mean heart dose of 37%–75% for FB versus DIBH (review by Latty et al. 2014).

• Other studies have reported decreases in several additional dose-volume metrics, e.g., Comsa et al. 2014.

<table>
<thead>
<tr>
<th>Metric</th>
<th>FB</th>
<th>DIBH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Dose (Gy)</td>
<td>3.05 ± 1.12</td>
<td>1.16 ± 0.39</td>
</tr>
<tr>
<td>V_{30Gy} (%)</td>
<td>2 ± 2</td>
<td>0.04 ± 0.07</td>
</tr>
<tr>
<td>V_{10Gy} (%)</td>
<td>6 ± 3</td>
<td>0.9 ± 0.9</td>
</tr>
</tbody>
</table>

Data from Table 2, Comsa et al. 2014

Anatomic Changes during DIBH - Lungs

How much dose the lung volume increase?

• In a large clinical study of breast cancer patients, Nissen et al. (2012) reported ipsilateral lung volume was ~2X greater for DIBH compared with FB.

<table>
<thead>
<tr>
<th>Lung Metrics</th>
<th>FB Left-Sided</th>
<th>DIBH Left-Sided</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>144</td>
<td>83</td>
</tr>
<tr>
<td>Volume median (cc)</td>
<td>2156</td>
<td>1247</td>
</tr>
<tr>
<td>Volume range (cc)</td>
<td>(1520 – 3120)</td>
<td>(670 – 1666)</td>
</tr>
</tbody>
</table>

Dosimetric Consequences of DIBH - Lungs

• Comsa et al. (2014) reported a statistically significant decrease (p<0.001) in lung dose-volume metrics.

<table>
<thead>
<tr>
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<th>DIBH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Dose (Gy)</td>
<td>14.26 ± 2.83</td>
<td>11.16 ± 1.99</td>
</tr>
<tr>
<td>V_{20Gy} (%)</td>
<td>28 ± 6</td>
<td>22 ± 5</td>
</tr>
<tr>
<td>V_{50Gy} (%)</td>
<td>35 ± 6</td>
<td>29 ± 5</td>
</tr>
<tr>
<td>V_{5Gy} (%)</td>
<td>45 ± 6</td>
<td>40 ± 5</td>
</tr>
</tbody>
</table>

Data from Table 2, Comsa et al. 2014

• Similar findings were reported in other studies, e.g., Remouchamps et al. (2003)
Summary

• During DIBH:
  – The heart is displaced, increasing the distance between the heart and the breast/chest wall tissue.
  – Air is drawn into the thoracic cavity, increasing the total lung volume.

• These anatomic changes lead to improved dose volume metrics for both the heart and the lungs for DIBH compared with FB breast radiation therapy.

Up Next...

Four DIBH Techniques:
1. Active breathing control
2. Spirometric motion management
3. 3D surface image-guided
4. Self-held breath control with respiratory monitoring and feedback guidance

Topic Overview:
• Technical aspects
• Simulation and treatment workflow
• Commissioning and routine quality assurance
• Practical tips

References