Accuracy of Breath-Hold CT for lung SBRT treatment planning

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CyberKnife radiosurgery is an effective treatment approach for lung SBRT.

Tumor motion can be tracked with Synchrony system using:
- Gold markers (Fiducials).
- kV images of the lung tumors (Xsight Lung).

Tumor with minimal breathing movement located close to the spine can be treated with an internal target volume (ITV) technique (Xsight Spine).
Treatment planning

1. Four-dimensional computed tomography (4DCT) scan during free breathing (FB) to evaluate tumor range of motion.
2. Breath-hold (BH) CT scan used for dose calculation.

**Figure:** Principle of retrospective sorting for reconstruction of 4DCT.
Treatment planning - Ideal Breath-hold CT

**Criterion 1:** BH at end-expiration (EE).
**Criterion 2:** BH standing within natural tumor trajectory.

![CT/CT images fusion of case 46](image_url)

**Figure:** CT/CT images fusion of case 46.
Objectives

To measure tumor position on BH CT scans according to natural tumor path during FB and to evaluate the benefits of the breathing cycle monitoring device Abches.

(a) Indicator unit  (b) Arms with chest and abdominal contacts

**Figure:** Abches device [1]
In 53 lung cancer patients, 4DCT and BH CT images were obtained.

- For 12 patients, BH CT scan was acquired using Abches.

Tumor motion was assessed by using local rigid registration of region of interest with Syntegra software from Philips.

Tumor motion was modeled as a linear movement.

- Patients showing significant hysteresis trajectory on 4D analysis were excluded.
Criterion no 2: BH standing within natural trajectory

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<thead>
<tr>
<th></th>
<th>No Abches</th>
<th>Abches</th>
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<tbody>
<tr>
<td>in</td>
<td>31 (75%)</td>
<td>9 (75%)</td>
</tr>
<tr>
<td>out</td>
<td>10</td>
<td>3</td>
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<tr>
<td><strong>tot</strong></td>
<td><strong>41</strong></td>
<td><strong>12</strong></td>
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**Table:** BH standing within natural tumor trajectory ($\delta_\perp = 3\,\text{mm}$)
Criterion no 2: BH standing within natural trajectory
Case 2 (RUL, Fiducials, Abches, \(d_\perp \approx 10\text{ mm}\))

(a) EI → EE
(b) BH → EE

Figure: CT/CT images fusion of case 2
Dosimetric impacts of marginal BH

**Dosimetric impacts**

**Tracking:**
- Using marginal BH CT for dose calculation could result in an underestimation of the effective dose to organ at risk (OAR).

**ITV technique:**
- Both BH and extreme phases of the 4DCT are included in IGTV delineation.
- Marginal BH may result in significant increase in treatment volume.
Tumor position during BH CT may not accurately correspond to positions observed on FB 4DCT, cases done with Abchies included.

Accurate and custom 4D analysis for each individual patient is recommended for treatment planning.

Dosimetric impacts must be assessed during treatment planning.

The benefits of using Abchies would need further evaluation in a larger cohort of patients.
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A simple respiratory indicator for irradiation during voluntary breath holding: a one-touch device without electronic materials