VARIATIONS OF PERICARDIUM DOSE AT
DIFFERENT RESPIRATORY STATUS IN
CYBERKNIFE M6™ TREATMENT PLANS FOR
ACCELERATED PARTIAL BREAST
IRRADIATION (APBI)

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Disclaimer

🎧 No funding was provided for this research.

🎧 No conflict of interest.
Outline

- Introduction
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- Conclusive Remarks
The Cyberknife robotic assisted radiation delivery system consists of a light weight 6 MV X-band linear accelerator mounted to a robotic arm. The robotic arm has six degrees of freedom that allow for an image-guided tracking system which can follow a target that moves with respiration with great precision\textsuperscript{1,2}.
Purpose

This study was designed to investigate the changes in pericardium dose at each respiratory phase or status during respiration cycle.
Six unidentified patients’ records with four-dimensional computed tomography (4DCT) sets, and six with a pair of free-breathing and deep breath-hold (BH) CT sets were used for dosimetry comparisons.

4DCT sets were obtained by Siemens™ CT and its respiratory gating system, comprising of 8 phases (1-0% Inhalation, 2-25% In, 3-50% In, 4-75% In, 5-100% In, 6-25% Exhalation, 7-50% Ex, 8-75% Ex).
CT sets for each patient were fused along the sternum and chest wall.

For the purpose of this study, the tumor volume was outlined in the media-lower quadrant of the left breast.
Methods and Materials

The heart positions were contoured for each phase thereafter, and recalculated with the same optimized base plan, 100% Inhalation phase, with the assumption that this phase would represent the greatest separation between the pericardium and tumor.

Standard APBI plan at 340 cGy had been delivered per fraction per protocol NSABP B-39/RTOG 04133 and modulated with Cyberknife M6™ on MultiPlan™ 5.1.2.
Breath Hold CT

Figure 1: 100% Inhalation (Red) vs. 0% Inhalation (Pink)
Breath Hold CT

Normalized Pericardium Dose vs Respiratory Phase

(1-0% Inhalation, 5-100% In)
Figure 2: 100% Inhalation (Red) vs. 75% Inhalation (Purple)
Normalized Pericardium Dose vs. Respiratory Phase

(1-0% Inhalation, 2-25% In, 3-50% In, 4-75% In, 5-100% In, 6-25% Exhalation, 7-50% Ex, 8-75% Ex)
The ANOVA test was used to determine whether the respiratory phases had influenced the cardiac dose for each volume.

The t-test was used to compare the means of the max-inhaled phases to the other phases, in order to determine if the means were significantly different.
Results

Except for the dose for a volume of 5cc (D5cc) in plans with 4DCT, the cardiac doses are significantly different between respiratory phases in well inhaled breathing phases, and even more significantly different in plans with BHCT.
## Results

<table>
<thead>
<tr>
<th></th>
<th>$D_{1cc}$</th>
<th>$D_{2cc}$</th>
<th>$D_{3cc}$</th>
<th>$D_{4cc}$</th>
<th>$D_{5cc}$</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sum of Square</strong></td>
<td>0.2548</td>
<td>0.1706</td>
<td>0.0823</td>
<td>0.0447</td>
<td>0.0249</td>
</tr>
<tr>
<td><strong>ANOVA P-value</strong></td>
<td>0.005</td>
<td>0.004</td>
<td>0.011</td>
<td>0.021</td>
<td>0.109</td>
</tr>
<tr>
<td><strong>Mean_{Max Inhale}</strong></td>
<td>0.836</td>
<td>0.902</td>
<td>0.931</td>
<td>0.947</td>
<td>0.951</td>
</tr>
<tr>
<td><strong>Mean_{Other Phases}</strong></td>
<td>1.023</td>
<td>1.014</td>
<td>1.010</td>
<td>1.008</td>
<td>1.007</td>
</tr>
<tr>
<td><strong>t-Test, $P_{2-tailed}$</strong></td>
<td>0.017</td>
<td>0.005</td>
<td>0.010</td>
<td>0.010</td>
<td>N/A</td>
</tr>
</tbody>
</table>
The cardiac doses were normalized to the mean cardiac dose for each volume. Mean cardiac doses in 100% inhalation phase were often found to be 5-15% (p<0.02) less than those in other phases.
A reduction in cardiac dose was seen for well-inhaled phases. This cardiac dose reduction provides practical guidance for cardiac dose reduction applicable with CK M6 APBI. Possible applications include:

- Coaching patient to breath with emphasis on inhalation.
- Placing a heart constraint on the total heart (the sum of all the heart positions during each respiratory phase).
- This is a work in progress.
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Thank You!

Questions?