Impact of Intentional LAD-Blocked Tangents for Enhanced Cardiac Sparing in Left Breast Radiotherapy

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ABSTRACT

Purpose: To determine whether adjusting MLC blocking of the left anterior descending artery (LAD) in left breast radiotherapy plans can reduce heart and LAD doses and improve plan robustness while maintaining desired target coverage.

Methods: 15 left breast radiotherapy patients, who had free breathing and breath hold 3DCRT plans, were chosen for this retrospective study. The MLC leaves on all fields were adjusted to cover the LAD without compromising clinical coverage goals or reducing the D95% of the lumpectomy PTV and whole breast volume by more than 1% and 1.5%, respectively. For patients who were identified as having a high risk of local recurrence, the MLC blocking was adjusted to not occlude the whole breast volume from the beam's-eye-view. In the free breathing plans, the mean and maximum LAD and heart doses were computed and compared to the planned doses prior to adjusting the MLC blocking. A dose perturbation function was used to simulate varying levels of breath hold, and the change in the mean LAD dose, averaged across all patients, was determined.

Results: The heart mean dose was reduced by an average of 63 cGy in the free breathing plans. LAD mean dose was reduced by 766 cGy, on average. LAD mean dose was also decreased in the breath hold plans, and the relative increase in the LAD mean dose with displacements of the heart towards the chest wall was smaller after adjusting the MLC blocking, compared to the original plan.

Conclusions: This work indicates that LAD and heart doses for left breast radiotherapy patients can be reduced through adjusting MLC blocking without compromising clinical coverage goals. Breath hold plans were also found to be more robust to varying levels of breath hold.

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INTRODUCTION

- The risk of major cardiac events following left breast radiotherapy is correlated with the mean heart dose (MHD)[1]
- However, high relative incidences of cardiac events have been observed in patients who did not receive high MHDs but had large dose hotspots in key cardiac substructures, like the left anterior descending artery (LAD)[2]
- One technique for reducing cardiac dose in left breast radiotherapy is the deep inspiration breath hold (DIBH). This moves the heart away from the field of a conventional paired oblique beam treatment relative to the free breathing (FB) position. Depending on the level of breath hold, the heart's position can change, even within the same fraction[3]
- **We sought to answer two questions in this study:**
  - **Can blocking the LAD in FB left breast radiotherapy plans lead to a significant reduction in LAD and heart mean doses, while preserving target coverage?**
  - **Can blocking the LAD in DIBH plans result in plans that are more robust to intrafraction and interfraction positioning variability?**

METHODS AND MATERIALS

- Retrospective study of 15 left breast 3DCRT patients who had both FB and DIBH plans
- All doses in this study were computed using the RayStation treatment planning system
- The MLC blocking of both the medial and lateral oblique fields was adjusted to cover as much of the LAD as possible while meeting the following criteria
  - < 1% reduction in $D_{95\%}$ for Lumpectomy PTV
  - < 1.5% reduction in $D_{95\%}$ for Whole Breast EVAL
  - Coverage goals still met
- Special attention was given to patients who had high-risk breast cancer. The MLC blocking for those patients was adjusted to not cover any of the clinical target volumes
- Example blocking for low-risk patients and high-risk patients are shown in Figures 1 and 2, respectively
- Mean heart, mean LAD, and maximum LAD doses were computed for all patients in both the FB and DIBH plans
- The *Compute perturbed dose* function was used to simulate the impact of patient shifts on cardiac dose in the DIBH plans

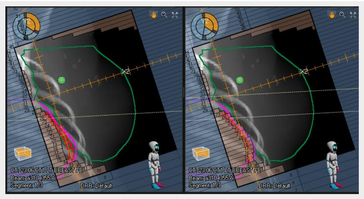

Figure 1. Beam's-eye-view of the MLC leaf patterns from an original plan (left) and the corresponding modified plan (right). The contours are the LAD (red), heart (pink), and whole breast volume (green)

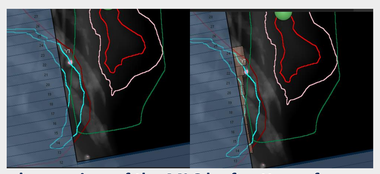

Figure 2. Beam's-eye-view of the MLC leaf patterns from an original plan (left) and the corresponding modified plan (right) for a high-risk breast cancer patient. The LAD is light blue in these images

RESULTS

- Average dose reductions in FB plans:
  - Heart Mean Dose – 63 ± 15 cGy
  - LAD Mean Dose – 766 ± 157 cGy
  - LAD Maximum Dose – 886 ± 251 cGy
- Box plots of the initial and final mean and maximum LAD doses are provided in Figure 3
- The average mean LAD dose in DIBH plans was also reduced from 693 cGy to 474 cGy
- The change in the average LAD mean dose as a function heart displacement in the DIBH plans is shown in Figure 4. The LAD mean doses in the adjusted plans were less sensitive to heart displacements compared to the original plans
- Change in mean heart doses in both plans for all patients is shown in Figure 5.

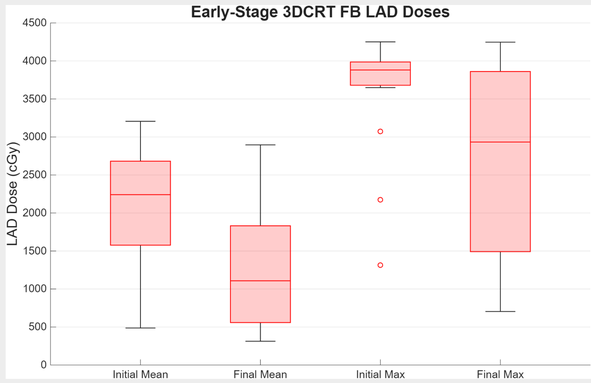

Figure 3. Mean and maximum LAD doses for FB plans, before and after adjusting MLC blocking

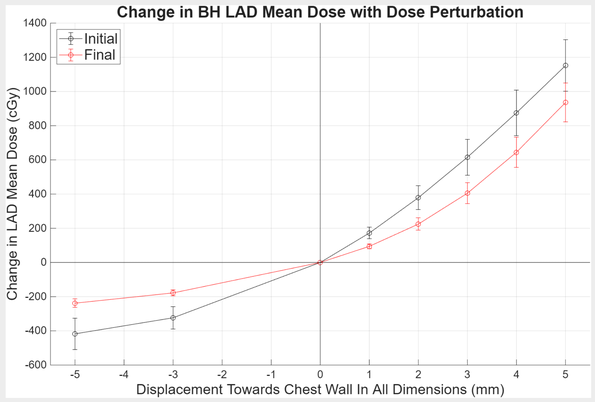

Figure 4: Change in LAD mean dose as a function of heart displacement for the original and modified plans

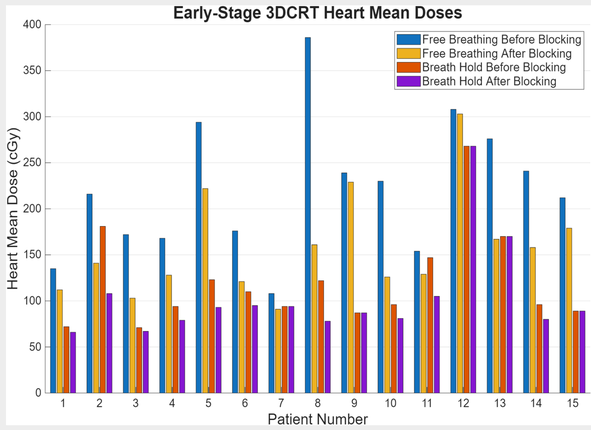

Figure 5: FB and DIBH mean heart doses, before and after using the MLC leaves to block the LAD

DISCUSSION

- For 3 of the 15 patients, the MLC blocking could not be substantially adjusted due to the proximity of the cardiac structures to the field and those patients' high risk of local recurrence at the posterior edge of the whole breast volume
- For all cardiac doses investigated in this study, statistically significant reductions were observed after adjusting MLC blocking
  - Assuming 1 Gy reduction in MHD corresponds to a 7% reduced risk of major adverse cardiac events, then an average 63 cGy reduction in MHD would result in an approximately 4.4% lower risk of major adverse cardiac events[1]
- For 5 mm displacements anteriorly, laterally, and superiorly towards the chest wall, the change in the LAD mean doses in the DIBH plans was reduced by approximately 216 cGy
- Patients 3, 6, 10, and 13 experienced a significant reduction in the MHD for the FB plans, such that the FB plans would have been selected for treatment over the DIBH plans based on our institutional guidelines
  - This would reduce treatment times and increase patient comfort

CONCLUSIONS

- **Significant reductions in cardiac dose in both FB and DIBH plans were observed after adjusting MLC blocking of the LAD, without compromising clinical coverage goals**
- **DIBH plans were also more robust to differences in patient positioning from varying levels of breath hold, reducing the risk of major adverse cardiac events for patients who are inconsistent with their level of breath hold**
- The dose reduction in FB plans was comparable to savings gained from using breath hold techniques, which will incentivize the use of FB plans over DIBH plans, improving patient comfort and speeding up treatment delivery
- MLC blocking for some patients was not able to be substantially adjusted due to concerns over the risk of local recurrence in the posterior region of the treatment field

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DISCLOSURES

The authors have no disclosures.