Use of 4DCT scans to create improved custom cardiac blocks for left sided breast cancer treatments

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INTRODUCTION

Radiation treatment for left sided breast cancer has been shown to increase cardiac toxicity such as myocardial infarctions, congestive heart failure and pericarditis. In a study of women treated for left breast cancer from 1958-2001 there was a 7.5% increase of the rate of major coronary events per gray of radiation to the heart[1]. A study using more recent radiation techniques examined 910 patients treated from 2005-2008 found the rate to be 16.5% per gray[2].

We present a new method for cardiac blocking based on larger heart blocks obtained from a 4DCT scan. These blocks spare more dose to the heart than conventional 3D heart blocks and are made to be patient specific.

METHOD

Einstein Medical Center has clinically implemented an IRB protocol to 4DCT scan each patient receiving treatment to the left breast or chest wall. Dosimetry plans these patients with a tangent based breast treatment with a custom MLC heart block based on the Maximum Intensity Pixel (MIP) heart contour obtained from the 4D scan. The treatment plans meet all objectives of a standard breast case and patients are treated as normal. Patients are setup using tattoos and MV images. 20 patients were retrospectively studied to see how using a MIP heart contour changed the block size and plan DVH from standard 3D plans.

Varian's Eclipse treatment planning system was used to fit standard MLCs to the 3D and MIP heart contours for each patient studied with no optimization. The MLC leaves not involved in the heart block (i.e. those that were under the jaws) were manually dragged closed. An example of a patient is shown in **figure 1**. For the purposes of measuring block size, the area not covered by the MLCs corresponds to the area of the block for a normal treatment. Using the MLC export tool, the leaf positions of those leaves involved in the heart block were analyzed and the differences in position and area between the 4D MIP heart blocks and the 3D heart blocks was found. The results for these differences are presented in **table 1**.

A 3D heart block was also retrospectively created and the plans were recalculated with this smaller block. Corresponding dose information is presented in **table 2**.

CURRENT CLINICAL APPROACHES

Deep Inspiration Breath Hold (DIBH)
- Most adults in the United States can only hold their breath 25-35 seconds[3,4]
- Mental, physical and anatomical limitations prevent some patients from being candidates

Prone Treatment
- Board cannot fit all patient sizes or accommodate all cancers

Custom MLC Heart Blocks for each patient
- Planned from a 3D scan

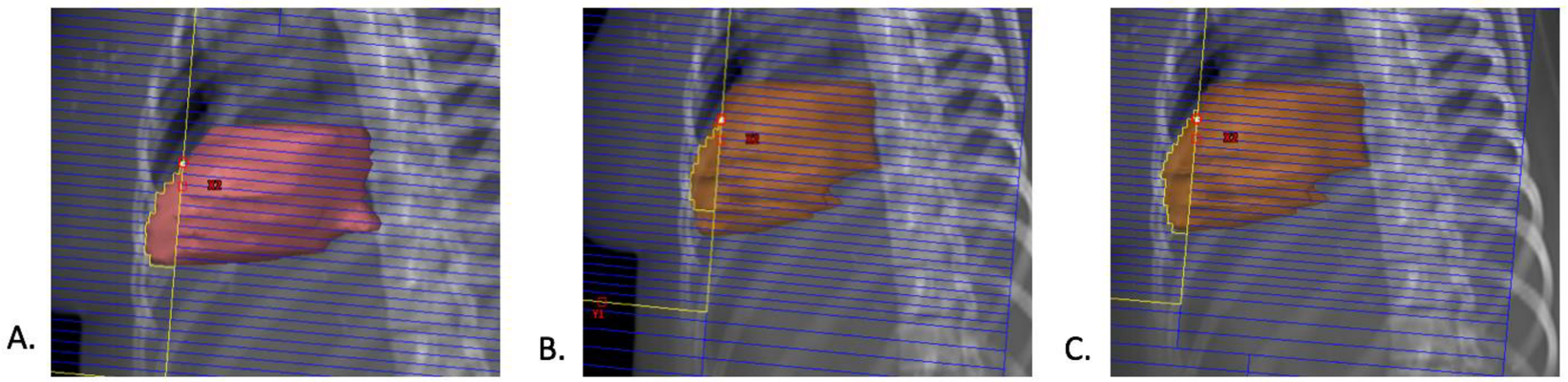

Figure 1: Images from Eclipse TPS for a patient where the MLCs have been manipulated to calculate heart block sizes. The opening of the MLCs corresponds to the size of the block. An example of the heart block for the 3D heart is in (A). (B) shows the MIP heart contour with the 3D block and the large portion that is not covered with the heart block. (C) shows an example of the MIP heart block.

BLOCK RESULTS

TABLE 1	Medial Field Block size Increase (cm^2)	Lateral Field Block size Increase (cm^2)	Medial Field Leaf Difference* (mm)	Lateral Field Leaf Difference* (mm)	Average Leaf Difference Both Fields (mm)
Mean**	1.36	1.22	4.4	3.4	3.9
Maximum**	3.71	2.94	20.8	11.5	16.2

* These differences are calculated by taking the difference in position between corresponding leaves in the MIP and 3D heart blocks and then taking the average of those positional differences for each patient

** The mean value represents the mean change for all of the patients looked at and maximum value represents the values for the patient that had the largest change.

DOSE RESULTS

TABLE 2	Change in Heart Dose (cGy) from the Treated Plan [$MIP_{volume\ dose}$ - $3D_{volume\ dose}$]		Change in MIP Heart Dose (cGy) [$MIP_{3D\ re\text{-}plan}$ – $MIP_{4D\ plan}$]	
	Mean Dose	Max Dose	Mean Dose	Max Dose
Patient Mean	17.8	766.8	16.2	754.3
Patient Maximum	70.3	2718.5	44.77	1543
Patient Minimum	0.2	-22.6	1.8	15.3

CONCLUSION

A new technique is presented that can reduce mean heart dose during left breast cancer treatment. Custom heart blocks are created for each patient that account for the motion of the heart due to breathing and cardiac cycles by using a MIP contour as an improvement to the MLC heart blocks made from 3D heart contours.

It is recommended that if 4DCT capability is not available, a 2.35cm^2 increase in the area of the block for both fields is created. This increase would cover the MIP for 95% of patients studied.

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