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Research Article

A Study to Lower the Left Anterior Descending Coronary Artery Dose in Left Breast Irradiation

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Abstract

Purpose: *To evaluate if contouring of the LAD artery as an OAR and avoidance of the artery by treatment planning optimization minimizes the LAD artery dose in cases of left-sided breast cancer irradiation.*

Methods and Materials: *Fifty-two patients diagnosed with left-sided Breast cancer were treated at Apollo Cancer Center, Bangalore between January 2021 to May 2022. The LAD was contoured prospectively for twenty-six patients (Arm A), and techniques were utilized to minimize LAD dose. Dose-volume-histograms from these patients were compared to those of twenty-six patients (Arm B) for whom the LAD was contoured retrospectively after treatment completion. EQD2 was calculated to account for fractionation differences.*

Results: *Comparing the dosimetric values of LAD in both groups, we found that median LAD D max in Arm A vs Arm B: 12.878 Gy vs 39.084 Gy (p-value 0.000000001243), median LAD D mean in Arm A vs Arm B: 4.504 Gy vs 16.711 Gy (p-value 0.00000002858). Comparison between prospective and retrospective groups shows prospective LAD contouring and optimization were associated with lower median D mean and D max LAD dose and were also statistically significant. Comparing the dosimetric values of the Heart in both groups, we found that median Heart D max in Arm A vs Arm B: 35.865 Gy vs 47.98 Gy (p-value 0.0000004440635), median Heart D mean in Arm A vs Arm B: 2.1802 Gy vs 2.8514 Gy (p-value 0.0197), Comparison between prospective and retrospective groups shows lower median D mean and D max Heart dose and were also statistically significant.*

Conclusion: *Our results show prospective contouring and avoidance of the LAD during treatment planning significantly reduce max and mean LAD dose without compromising coverage.*

Introduction

The world is experiencing a period of dramatic social, economic, and cultural changes resulting in, cancer ranking as a leading cause of death and an important barrier to increasing life expectancy in every country. Over the last few years, Breast Cancer (BC) incidence has been rising steadily among females, and now it is the most commonly diagnosed cancer and the leading cause of worldwide cancer death.

GLOBOCAN 2020 worldwide data showed 2,261,419 newly diagnosed Breast Carcinoma cases which is 11.7 % of total carcinoma cases and 684,996 deaths which is 6.9% of all site cancer. Breast cancer causes more women to lose disability-adjusted life years (DALYs) globally than any other type of cancer [1]. The incidence of breast cancer varies significantly by race, ethnicity, and geography. In a general radiation oncology practice, breast cancer typically comprises 25% of the total patient load.

Radiation Therapy (RT) forms an integral part of the Combined Modality Treatment of carcinoma breast which includes Surgery, Chemotherapy, Radiotherapy, and Hormonal therapy. Adjuvant Radiation therapy for Early Breast Cancer (EBC) significantly reduces the risk of Locoregional Recurrence (LRR) and Breast Cancer-related mortality following Breast Conservative Surgery (BCS) [2].

For locally advanced breast cancer (LABC), followed by mastectomy and neo- adjuvant/adjuvant chemotherapy, chest wall irradiation with regional nodal irradiation (RNI) has demonstrated a significant clinical benefit for local, regional, and distant disease control, as well as the overall survival of the patient [3] [4].

Cardiac toxicity can be caused by some chemotherapy drugs, such as Adriamycin and Trastuzumab. So further risks due to Radiotherapy must be counted. [5]. Cardiac toxicity following radiotherapy can manifest itself as (1) Pericarditis which takes about 1.5 to 4 years to develop and occurs mainly due to inflammation. (2)Ischemic heart disease, Myocardial infarctions tend to have a higher chance of occurrence after 3 years of irradiation. The cause has been hypothesized to be due to accelerated atherosclerosis.

(3) Arrhythmia occurs due to fibrosis/damage to the AV node and conduction system which takes 10-14 years to develop.

(4) Congestive heart disease and valvular disease develop mainly due to endomyocardial fibrosis and take more than 13 years post-irradiation to develop [6].

In the case of Left-sided Breast cancer, an important cause of morbidity and mortality is ischemic heart disease without breast cancer recurrence. Most significantly, the Left Anterior Descending Artery (LAD), which supplies most parts of the heart, may be located near the radiation beam edge in case of left breast cancer irradiation. Left-sided Breast cancer patients have a 51% higher rate of cardiac stress test abnormalities compared with right-sided Breast cancer, with 70% of the abnormalities occurring in the LAD artery, with stenosis rates at the mid and distal LAD artery significantly increased [7].

Traditionally in Breast cancer radiation, opposed tangential beams have been used. With the use of 3D Conformal Radiation Therapy (3DCRT), we can achieve good local control with a lower mean heart dose in left-sided breast cancer [8]. Hong L et al evaluated Intensity Modulated Radiation Therapy (IMRT) in Breast planning can provide dose homogeneity throughout the target volume and also reduce the dose to the Heart, Coronary arteries, Lung, opposite Breast, and surrounding soft tissues [9].

Additionally, in Deep Inspiratory Breath Hold (DIBH) versus Free-breathing (FB) in radiotherapy for left-sided breast cancer cases, it was found that using DIBH allows a significant reduction in both heart dose and LAD dose while maintaining adequate target coverage [10] [11].

Our study was to estimate and compare the doses of LAD artery with previously treated left- sided Breast cancer patients where LAD artery was neither contoured nor optimized with left- sided Breast cancer patients for whom LAD artery was prospectively contoured & dose optimized.

Aim of the study:

To minimize the Left Anterior Descending (LAD) Artery dose by

a) “Contouring of LAD artery” as an Organ at Risk (OAR) in the Radiation Therapy planning CT scan, and

b) Avoidance of LAD artery by “treatment planning Optimization

Objective of the study:

Comparison of the doses of LAD artery of the Prospective group whose LAD was contoured & dose optimized with retrospectively treated left-sided Breast cancer patients where Left Anterior Descending (LAD) Artery was neither contoured nor optimized.

Material and Method

This is a Prospective- Retrospective comparative dosimetric study conducted in the Department of Radiation Oncology, Apollo Cancer Centre, Bangalore, India between January 2021 to May 2022 after acquiring approval from the Institutional Scientific Review Board and Ethical Committee. Informed consent was taken from each of the patients recruited for this study.

Sample size calculation: estimated based on the difference in the proportion of subjects receiving LAD RT on unmodified plan mean of 42% and modified plan mean (LAD avoiding) at 6% from the study by Vivekanandan S et al [12]. Using these values in the below-mentioned formula

$$N = \frac{2\,(Z_{\alpha/2} + Z_{\beta})^2\, P\,(1-P)}{(p_1 - p_2)^2}$$

$Z_{\alpha/2} = Z_{0.05/2} = Z_{0.025} = 1.96$ at type 1 error of 5%

$Z_{\beta} = Z_{0.20} = 0.842$ = At 80% power

$p_1 - p_2$ = Difference in proportion in the two different groups = 36%

P= Pooled prevalence = [Proportion in Unmodified plan (p_1) + Proportion in modified plan(p_2)]/2 = [42 + 6]/2 = 24

$$N = \frac{2 \times 24 \times 76\,(1.96 + 0.84)^2}{36 \times 36} = 28600 / 1296 = 23 \text{ in each group}$$

Considering nonresponse rate of 10%, 23 + 2.3 = 25.3 ≈ 26 patients to be included in eachgroup.

Sample size recruited: 52 Patients were recruited according to sample size calculation. We had two study groups. The patient number for each group was 26.

Inclusion criteria:

- Patients having Left-sided Breast Cancer,
- Patients after Breast Conservation Surgery (BCS) or after Mastectomy,
- Patient before or after chemotherapy,
- KPS (Karnofsky Performance Scale) > 70

Exclusion criteria:

- Patients who have received Radiotherapy earlier to the chest/mediastinum/thorax,
- Bilateral Breast Cancers,
- Patients who have undergone Coronary Artery Bypass Grafting (CABG) or stenting to coronary artery

Study procedure:

Patient selection: Patients with left-sided Breast cancer were screened according to the above inclusion and exclusion criteria. The benefits, risks, and methods of the procedure were explained in detail and informed consent was obtained after explaining the procedure in detail. We have two study groups (Patient characteristics are listed in Table 1).

Arm A (Prospective group 26 patients): Left Breast carcinoma patients whose heart and LAD were contoured prospectively and included in treatment optimization.

Arm B (Retrospective group 26 patients): For patients who have already completed Left Breast irradiation in whom only the Heart was contoured and optimized before, LAD was not contoured.

Table 1: PATIENT CHARACTERISTICS [n=26 in each group, Total 52]

CHARACTERISTIC	STRATIFICATION	NUMBER OF PATIENTS	
		Prospective	**Retrospective**
Breathing pattern	FB	7	7
	DIBH	19	19
Treatment type	CF	6	8
	HF	20	18
Treatment technique	3DCRT	13	13
	IMRT	13	13

Radiotherapy planning: Arm A:

a) Preparation and Immobilization

After obtaining written informed consent patients were positioned in the supine position on the inclined breast stabilization cushion with arms above the head and aligned straight with the help of lasers (Figure 1)

Figure 1: Patient position photo

b) Simulation CT scan

Prior to the simulation scan, the patients were trained to hold a maximum deep breath for 16-18 seconds, in the treatment position. CT simulation scans were taken in free- breathing and in deep inspiratory breath-hold depending on the patient's breath-hold (19 prospective DIBH patients). For patients who are finding difficulty in breath-hold, only a free-breathing scan was taken (7 prospective FB patients). The images were imported into the Eclipse treatment planning system Version 11.0.31(Varian Medical Systems) for volume delineation and treatment planning.

c) Target volume and OAR delineation

Breast tissue, chest wall, and nodal delineation were contoured according to RTOG guidelines[13]. The Heart & LAD were contoured using a heart atlas. The LAD artery was contoured on the RT planning CT scan (on DIBH scan for 19 patients and on FB scan for 7 patients) immediately distal to its branch-point from the Left Main coronary artery along the anterior interventricular groove to the apex of the Heart using a published contouring atlas [14] [15] [16].

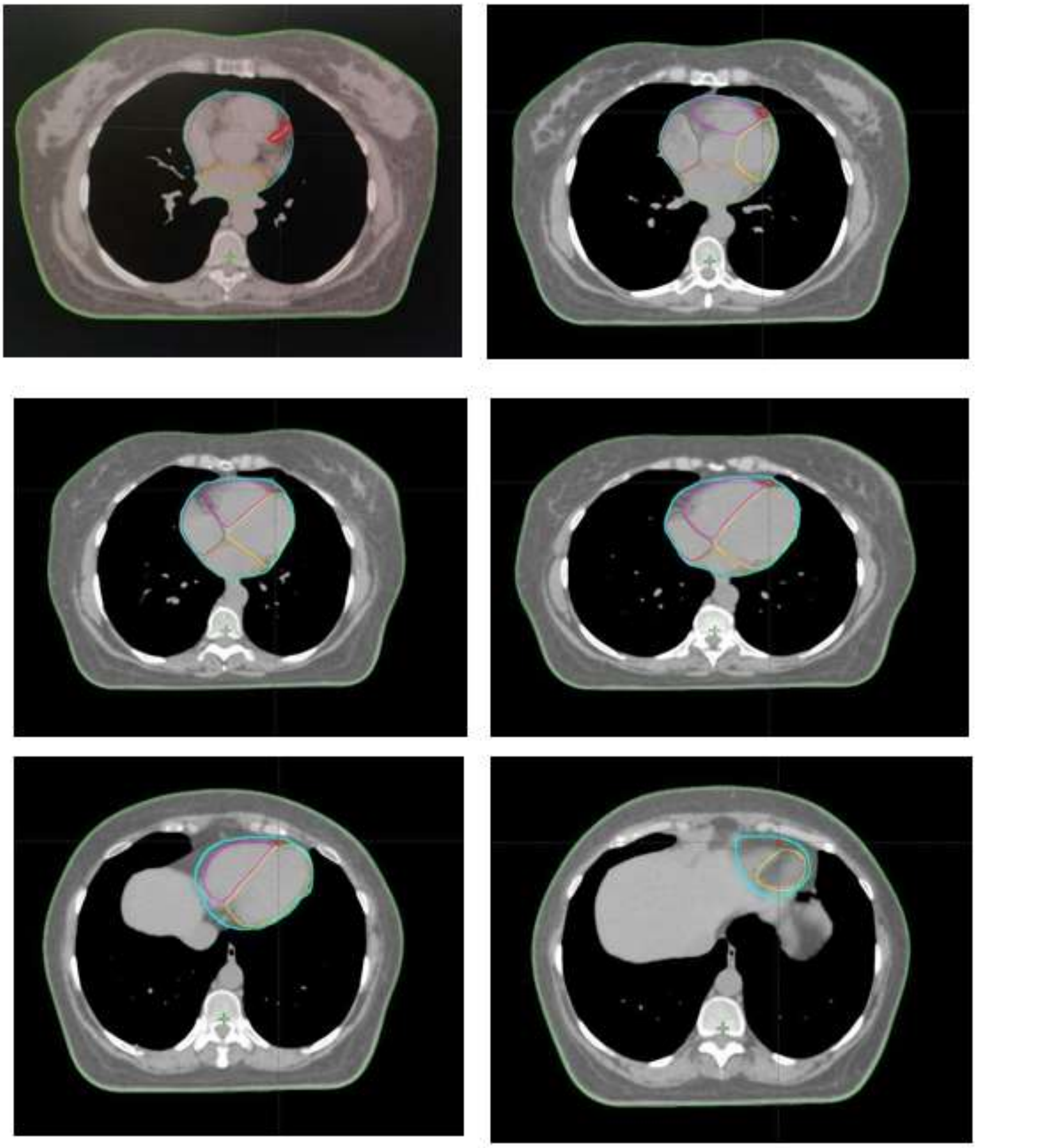

Figure 2: Image showing heart, LAD contour

d) Dose prescribed

The fractionation regimens were 40 Gy/15 Fr or 42.56 Gy/16 fractions or 50 to 50.4 Gy in 25 to 28 fractions. Boost to the lumpectomy cavity, when administered was 10 Gy in 4 to 5 fractions or 16 Gy in 8 fractions. Dose constraints were set as LAD: Goal: Mean: 2.5 Gy for Hypofractionation (HF), 3 Gy for Conventional fractionations (CF), MHD (Mean Heart Dose) 1.2 Gy if HF & 1.7 Gy if CF with an aim to achieve 95% dose to 100% planning target volume.

e) Radiotherapy planning

The treatment plan was carried out using a CT-based, Intensity-modulated Radiotherapy or 3-dimensional conformal radiotherapy. According to the patient's comfortable breathing pattern, planning was done either on FB or DIBH. Beam angle modification, collimator leaf adjustment, and planning optimization are utilized to minimize LAD and heart dose. Plan evaluation was done and if satisfactory Quality assurance was done and transferred for treatment execution.

f) Plan implementation

All patients were treated with photons on the Varian linear accelerator. Real-time position monitoring was used for DIBH patients.

Arm B: For our analysis, we have selected 19 DIBH patients and 7 FB patients retrospectively and contoured the LAD (according to the contouring recommendation mentioned above) on delivered treatment plans.

Parameters evaluated:

The following parameters were evaluated

a) Dmean of LAD

b) D max of LAD

c) Dmean of Heart

d) D max of Heart

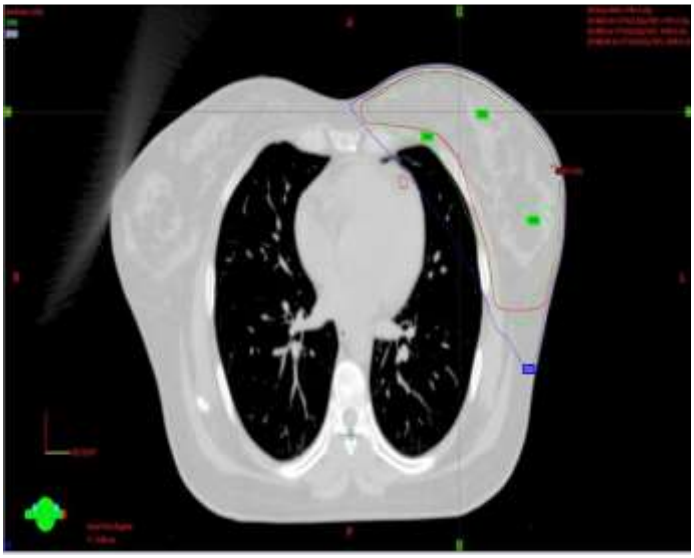

Figure 3a

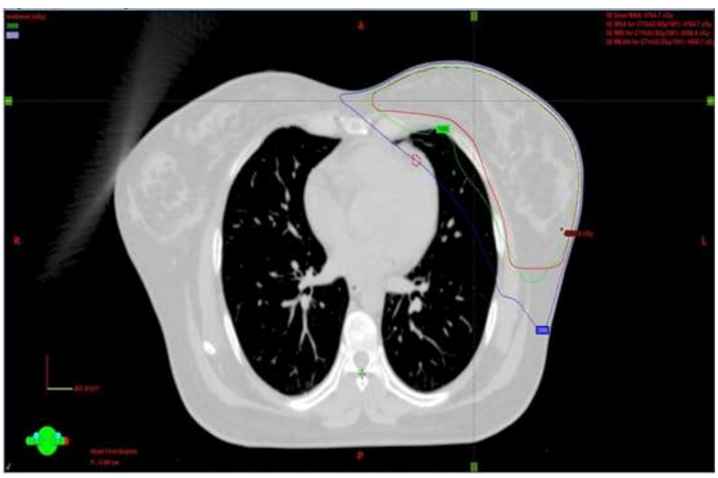

Figure 3b

Figure 3: a) LAD CONTOURED AND SPARED, b) LAD CONTOURED BUT NOT SPARED

Plan comparison:

Heart and LAD dose-volume-histogram (DVH) data from both groups (ARM A, ARM B) were compared. (figure 4)

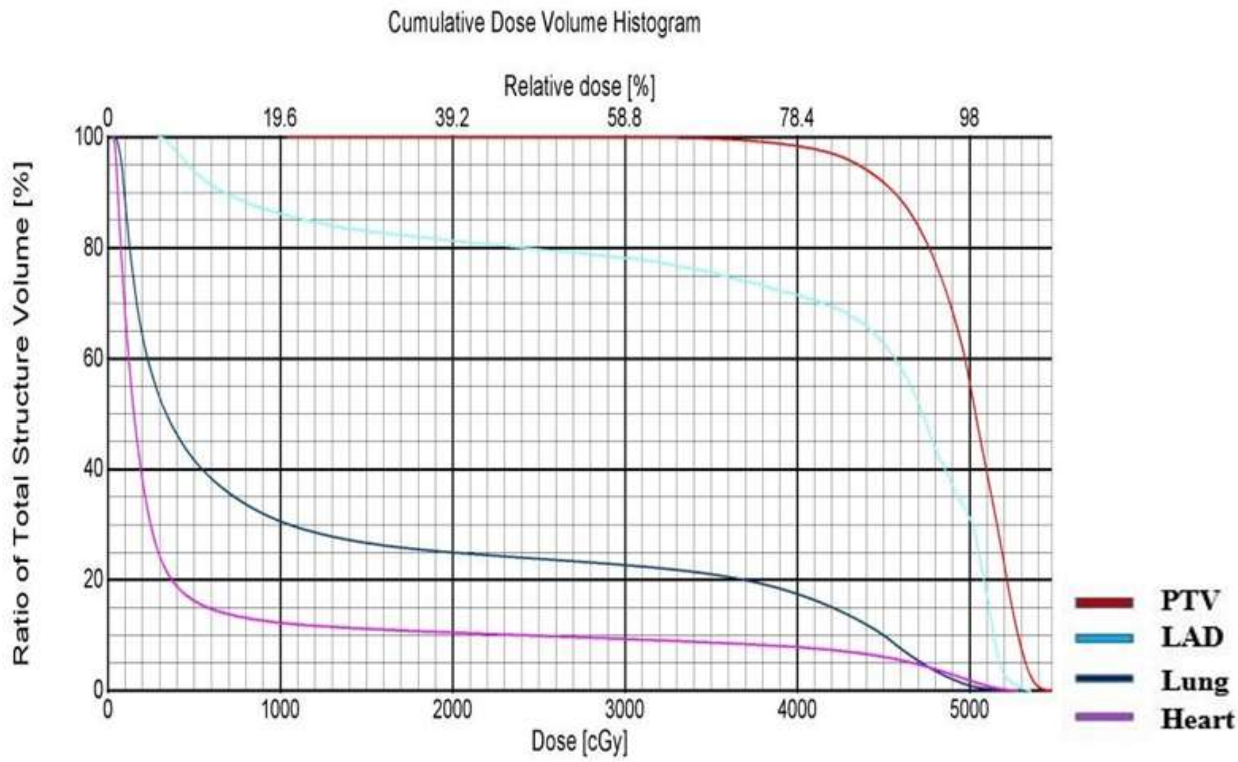

Figure 4a (Graph 1: DVH of one Retrospective patient)

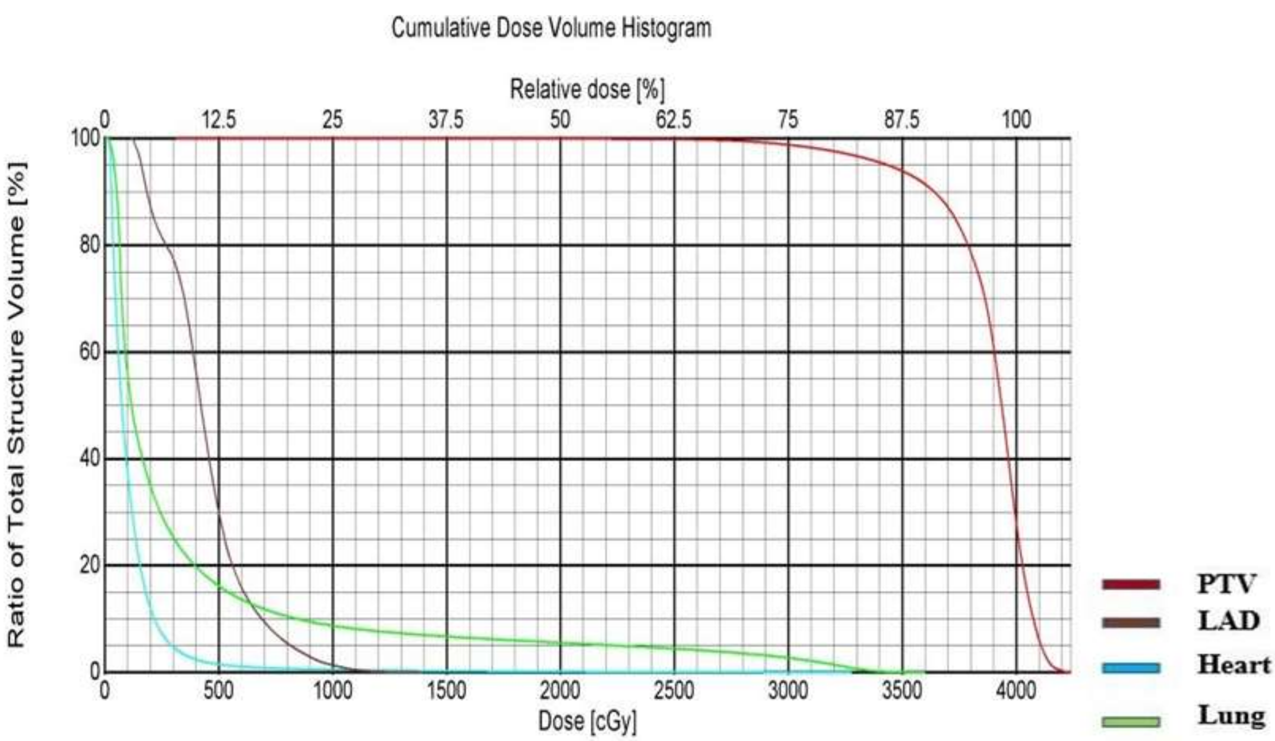

Figure 4b (Graph 2: DVH of one Prospective patient)

Statistical analysis:

- All the study data obtained through the study Proforma was entered into MS excel sheet and statistical software name R was used for the analysis of data.
- To compare the distribution between groups, the nonparametric Mann-Whitney U test was used.
- p-value <0.05 was considered statistically significant.
- When needed to account for differences in the proportion of patients receiving hypo fractionated versus conventionally fractionated treatment fractionation, doses were expressed as an EQD2 (Equivalent Dose).

$$EQD_2 = D\left(\frac{d + \alpha/\beta}{2 + \alpha/\beta}\right)$$

where D = composite dose, d = dose per fraction,

alpha/beta ratio = Linear and Quadratic component

2 taken as for late effects of heart and coronary vessels. [17]

Results:

Heart and LAD doses are listed in table 2,3,4. Comparing the dosimetric values of LAD in both groups, we found that median LAD D max in Arm A vs Arm B: 12.878 Gy vs 39.084 Gy (p- value 0.000000001243), median LAD D mean in Arm A vs Arm B: 4.504 Gy vs 16.711 Gy (p-value 0.00000002858). Comparison between prospective and retrospective groups shows prospective LAD contouring and optimization were associated with lower median D mean and D max LAD dose and were also statistically significant (figure 5,6). Comparing the dosimetric values of the Heart in both groups, we found that median Heart D max in Arm A vs Arm B: 35.865 Gy vs 47.98 Gy (p-value 0.0000004440635), median Heart D mean in Arm A vs Arm B: 2.1802 Gy vs 2.8514 Gy (p-value 0.0197). Comparison between prospective and retrospective groups shows lower median D mean and D max Heart dose and were also statistically significant (figure 7,8). Comparing the dosimetric values of LAD Dmean between two groups with DIBH, we found that Arm A vs Arm B: 4.751 Gy vs 11.708 Gy (p-value 0.00002192). Comparison between the two groups shows that the median D mean LAD dose was lower in the case of the prospective DIBH group and also statistically significant (figure 9). Comparing the dosimetric values of LAD Dmean between two groups with FB, we found that Arm A vs Arm B: 4.363 Gy vs 33.35 Gy (p-value 0.0005828). Comparison between the two groups shows that the median D mean LAD dose was lower in the case of the prospective FB group and also statistically significant (Figure 10).

Table 2: CHARACTERISTICS OF PROSPECTIVE AND RETROSPECTIVE EQD2 LAD DOSE								
DOSE IN GY	**PROSPECTIVE**				**RETROSPECTIVE**			
	MINIMUM	**MEDIAN**	**MAXIMUM**	**IQR**	**MINIMUM**	**MEDIAN**	**MAXIMUM**	**IQR**
Dmean	2.068	4.504	9.052	3.046 to 6.202	1.825	16.711	44.992	9.691 to 21.593
D max	3.99	12.878	27.007	9.092 to 15.547	7.708	39.084	62.467	33.146 to 45.786

Table 3: CHARACTERISTICS OF PROSPECTIVE AND RETROSPECTIVE EQD2 HEART DOSE								
DOSE IN GY	**PROSPECTIVE**				**RETROSPECTIVE**			
	MINIMUM	**MEDIAN**	**MAXIMUM**	**IQR**	**MINIMUM**	**MEDIAN**	**MAXIMUM**	**IQR**
Dmean	0.7727	2.1802	5.081	1.3159 to 3.2676	0.8443	2.8514	11.323	1.7359 to 6.2012
D max	9.214	35.865	48.083	23.046 to 41.092	24.86	47.98	67.07	44.34 to 50.77

Table 4: LAD DMEAN COMPARISON BETWEEN TWO GROUPS WITH DIFFERENT BREATHING PATTERNS				
LAD Dmean (Dose in Gy)	**DIBH**		**FB**	
	Prospective	Retrospective	Prospective	Retrospective
Minimum	2.068	1.825	2.716	18.43
Median	4.751	11.708	4.363	33.35
Maximum	9.025	22.709	9.052	44.99
IQR	2.835 to 6.733	8.678 to 18.387	4.215 to 5.038	27.43 to 41.76

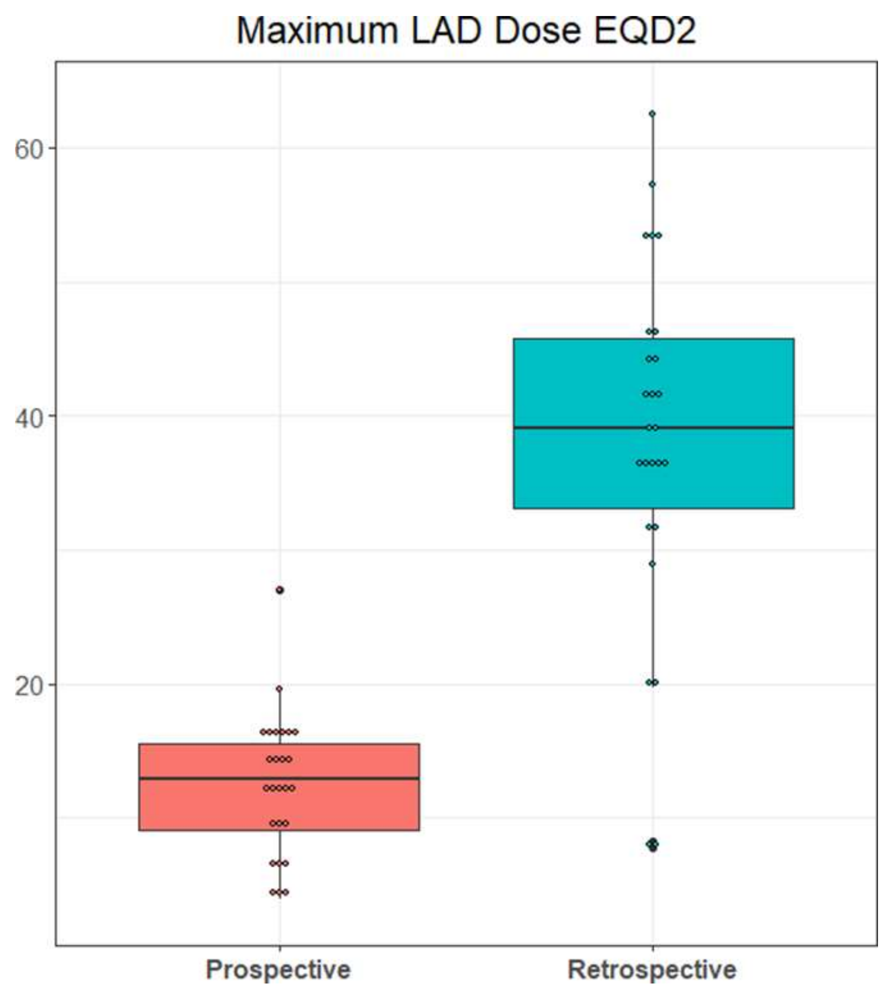

Figure 5: Comparison of max LAD dose between two group

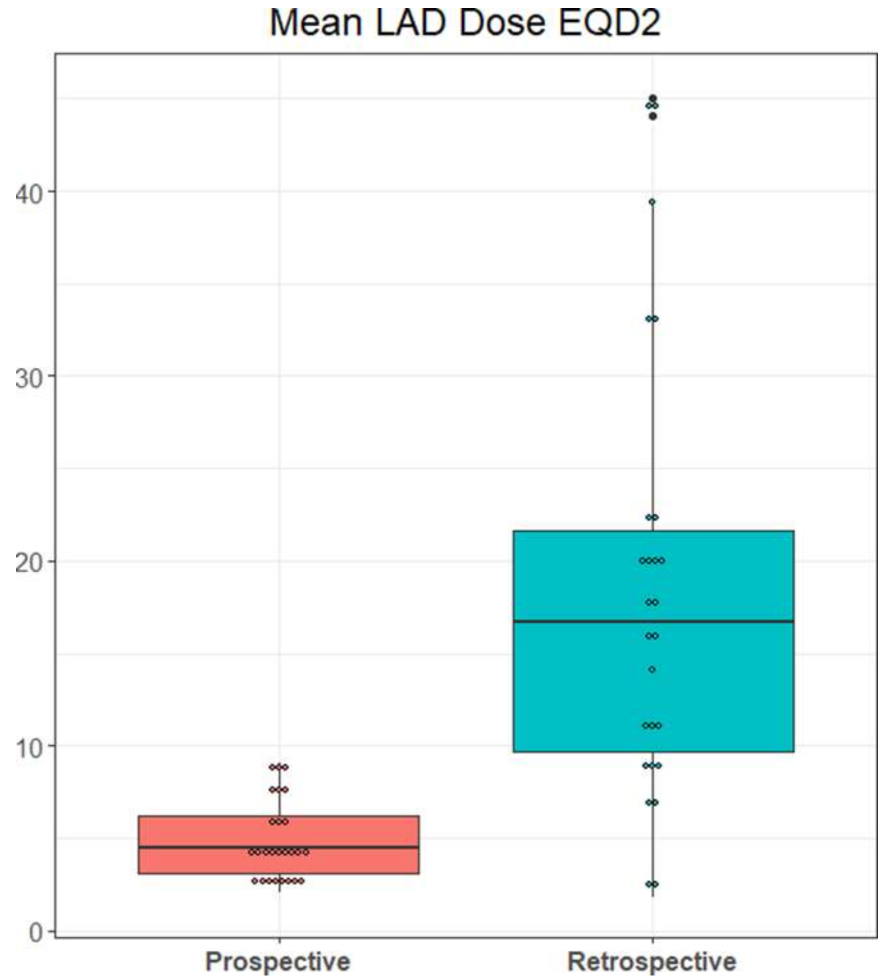

Figure 6: Comparison of mean LAD dose between two group

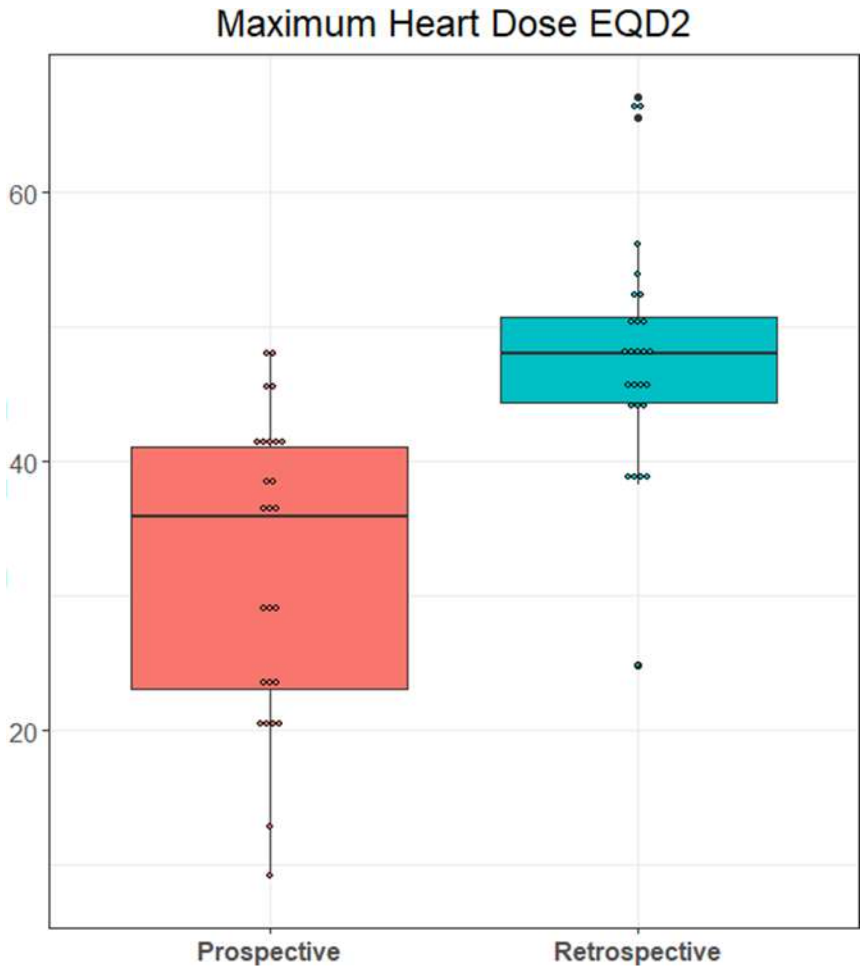

Figure 7: Comparison of max heart dose between two group

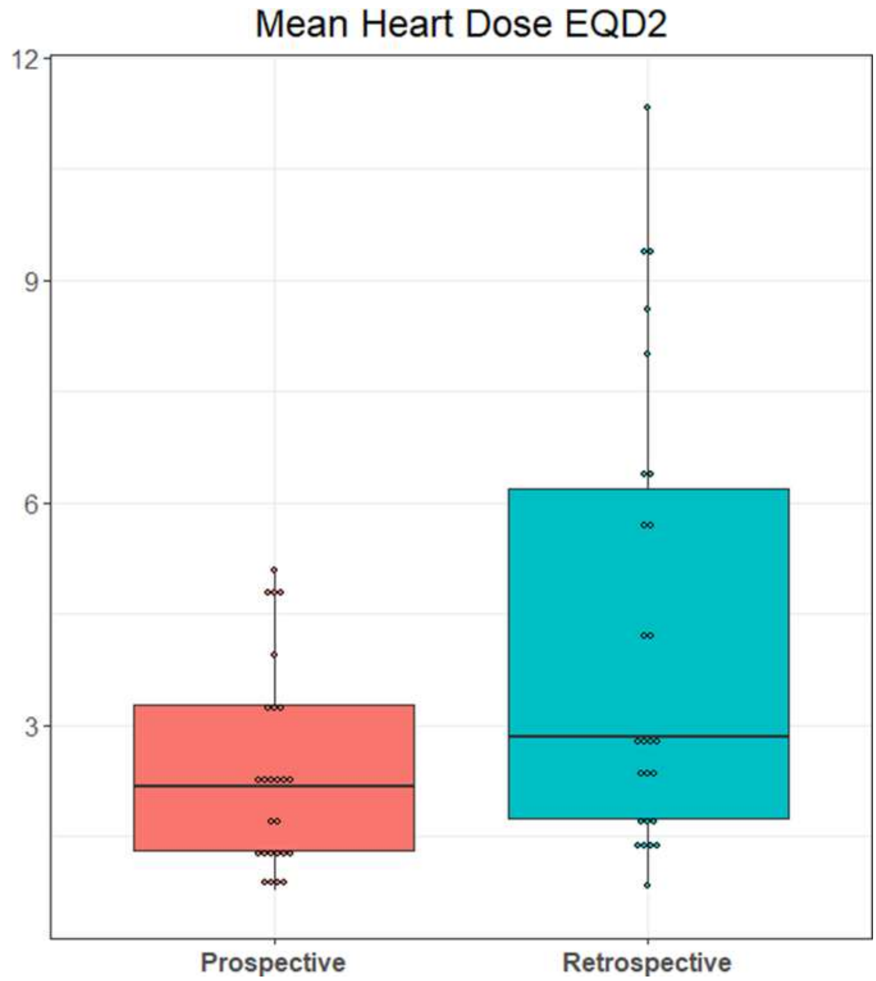

Figure 8: Comparison of mean heart dose between two group

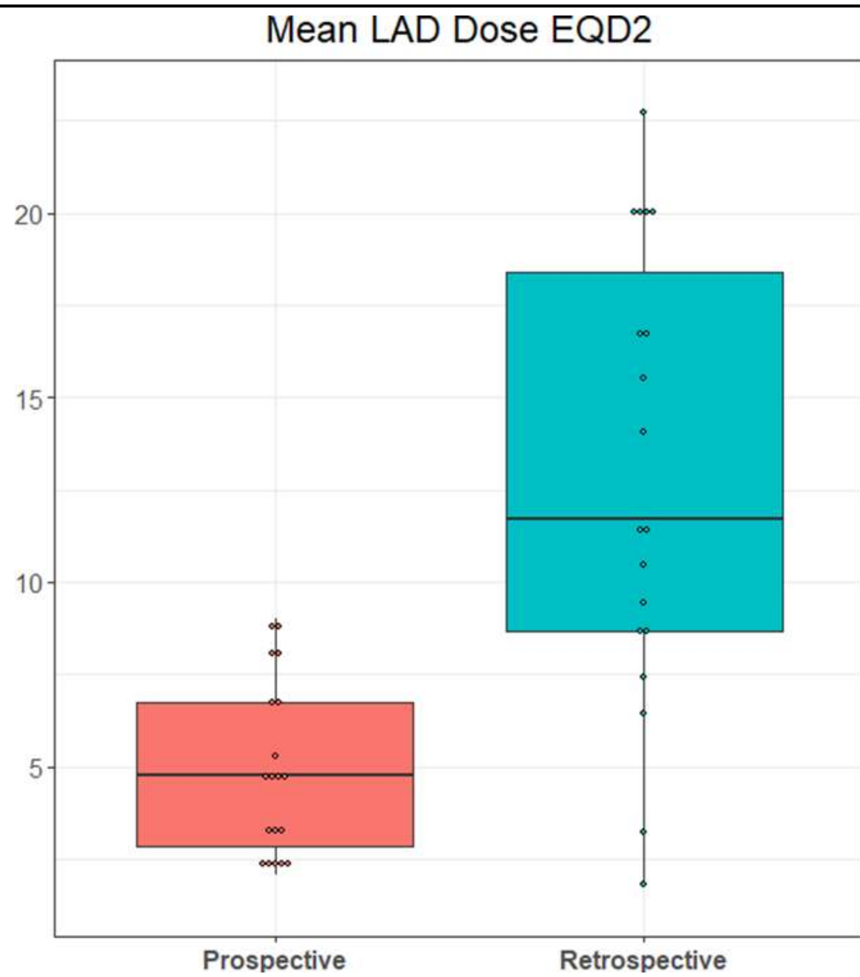

Figure 9: LAD Dmean comparison between two groups with DIBH

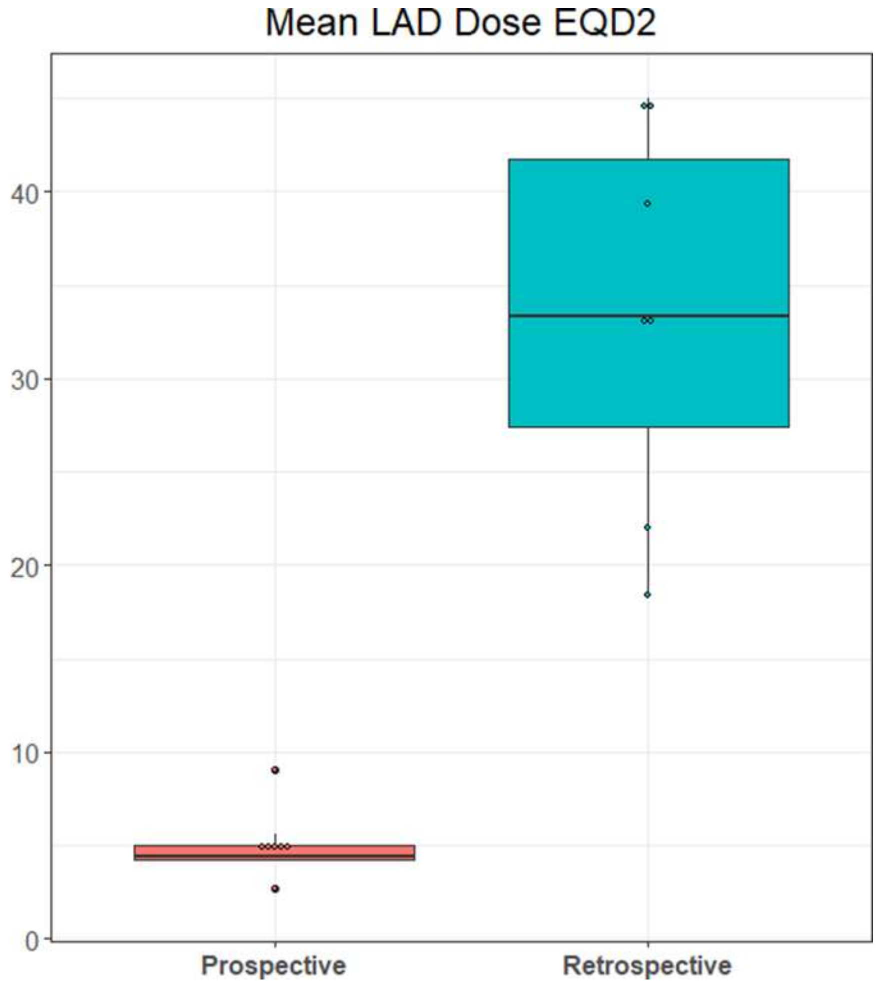

Figure 10: LAD Dmean comparison between two groups with FB

Discussion

In left-sided Breast cancer, adjuvant Radiotherapy is associated with an increase in the risk of cardiac injury as part of the Heart and LAD (Left Anterior Descending) artery comes within the treatment field.

Numerous studies have demonstrated an increased incidence of fatal coronary vascular disease among women treated with adjuvant radiation for left-sided breast cancer. Endothelial cell damage brought on by radiation exposure causes fibrosis, which in turn causes microvascular dysfunction. With dosages as low as 2 Gy, the endothelial cells react by secreting inflammatory markers and adhesion molecules that attract peripheral leukocytes. Increased size and quantity of these lesions in the major arteries are linked to a dosage of RT > 8 Gy. Additionally, the resulting plaques can be more brittle and macrophage-rich [18]. The most frequent reason for cardiac death from radiation is myocardial infarction [19][20][21]. In the case of breast cancer, there is no accepted dose restriction for the LAD. The DEGRO breast cancer expert panel suggests the following dose restrictions in light of the results of a meta-analysis performed by Piroth et al. MHD is 3 Gy, while the mean LAD is 10 Gy.

The mean dosage to the left anterior descending (LAD) artery was found to be a less accurate predictor of major coronary events than the mean heart dose in a previous study by Darby et al [22]. According to a study, women who underwent left-sided radiation therapy for breast cancer saw an increase in high-grade coronary artery stenosis in the LAD artery, demonstrating a direct correlation between radiotherapy and coronary artery stenosis [23].

Patients treated with more conformal radiation techniques in the recent past appear to have a lower risk of late cardiac injury; however, such patients still have a 10-year median follow-up, which may not be long enough to determine late cardiac injury [24][25].

Active breathing control and inverse planned, segmented radiation therapy, which were previously used to reduce Mean Heart Dosage, have been shown to reduce dose to the LAD artery. When used in left breast cancer irradiation, the DIBH approach effectively reduces radiation doses to the LAD area, heart, and lungs [26]. Despite the fact that DIBH is an effective heart-sparing treatment in breast RT, approximately one-third of patients do not benefit from it due to breathing difficulties [27].

<table>
<tr><th colspan="4">TABLE 14: STUDIES IN RELATION TO HEART AND LAD DOSES</th></tr>
<tr><th>STUDY NAME</th><th>STUDY METHOD</th><th>LAD DOSE IN GY</th><th>COMMENT</th></tr>
<tr>
<td>Lee et al [28]</td>
<td>A retrospective dosimetric analysis of 25 WBI patients was performed.

50.4 Gy/28 fractions was the prescribed dose.

They contoured the LAD, which included the LMCA, in retrospectively.</td>
<td><table>
<tr><th></th><th>LAD Dmean</th><th>Heart Dmean</th></tr>
<tr><td>DIBH</td><td>16.01</td><td>2.52</td></tr>
<tr><td>FB</td><td>26.26</td><td>4.53</td></tr>
</table></td>
<td>This resulted in greater absolute values because LMCA is incorporated into contouring.

The LAD mean dose was reduced as a result of active motion management.</td>
</tr>
</table>

<table>
<tr>
<td>Quirk S et al [29]</td>
<td>1221 individuals with BC on the left underwent a retrospective dosimetric examination of LAD dosage.

42.5 Gy in 16 fractions and 40 Gy in 16 fractions are the recommended doses.</td>
<td>
<table>
<tr><td></td><td>Heart Dmean</td><td>LAD Dmean</td></tr>
<tr><td colspan="3">IMN included</td></tr>
<tr><td>BH</td><td>1.0</td><td>3.6</td></tr>
<tr><td>FB</td><td>1.1</td><td>4.0</td></tr>
<tr><td colspan="3">IMN Excluded</td></tr>
<tr><td>BH</td><td>0.9</td><td>3.2</td></tr>
<tr><td>FB</td><td>0.9</td><td>3.8</td></tr>
</table>
</td>
<td>For LAD mean dose, a difference of 0.4 Gy and 0.6 Gy in the case of IMN were included and excluded respectively.

For the majority of patients, appropriate motion management can be used to achieve a low LAD D mean without sacrificing target coverage.</td>
</tr>
<tr>
<td>Mast et al [30]</td>
<td>This study includes 20 patients who underwent left-sided WBI (42.56 Gy/16 fractions).

FB 3D-CRT, FB IMRT, BH 3D-CRT, and BH IMRT are the four treatment plans that were created.</td>
<td>
<table>
<tr><td></td><td>Dmean</td><td>Dmax</td></tr>
<tr><td>3DCRT BH</td><td>9.6</td><td>25.3</td></tr>
<tr><td>IMRT BH</td><td>6.7</td><td>18.8</td></tr>
<tr><td>3DCRT FB</td><td>18.6</td><td>35.5</td></tr>
<tr><td>IMRT FB</td><td>14.9</td><td>31.4</td></tr>
</table>
</td>
<td>No dose adjustment (EQD2) for HF.

IMRT results in a significant additional decrease of dose in the heart and LAD in both BH and FB.</td>
</tr>
<tr>
<td>Aleksander V et al [31]</td>
<td>323 left-sided BC patients who received WBI or CWI underwent dosimetric analysis. In168 cases retrospectively LAD was contoured, and 155 prospective cases.</td>
<td>
<table>
<tr><td colspan="3">WBI</td></tr>
<tr><td></td><td>Dmax</td><td>Dmean</td></tr>
<tr><td>Prospective</td><td>2.99</td><td>1.48</td></tr>
<tr><td>Retrospective</td><td>5.15</td><td>1.92</td></tr>
<tr><td colspan="3">WBI + IMN</td></tr>
</table>
</td>
<td>EQD2 Calculated.

Avoidance of LAD by prospective contouring and optimization suggestively -

In the case of WBI-Reduces max and mean</td>
</tr>
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<tr>
<td></td>
<td>42.56 Gy in 16 fractions, or 50 to 50.4 Gy in 25 to 28 fractions, were the recommended dose.</td>
<td><table><tr><td></td><td>Dmax</td><td>Dmean</td></tr><tr><td>Prospective</td><td>9.16</td><td>3.44</td></tr><tr><td>Retrospective</td><td>14.25</td><td>3.47</td></tr></table></td>
<td>LAD dose, and in case of-WBI + IMN irradiation - Reduces max LAD dose, non-significantly reduces median mean LAD dose.</td>
</tr>
<tr>
<td>Our study</td>
<td>ARM A (prospective: 26 left BC cases): whose heart and LAD were contoured prospectively and included in treatment planning optimization.
ARM B (Retrospective: 26 left BC cases): previously completed irradiation with only the Heart contoured, but no LAD contouring.</td>
<td><table><tr><td>Dose in Gy</td><td>ARM A</td><td>ARM B</td></tr><tr><td colspan="3">LAD</td></tr><tr><td>Dmax</td><td>12.878</td><td>39.084</td></tr><tr><td>Dmean</td><td>4.504</td><td>16.711</td></tr><tr><td colspan="3">Heart</td></tr><tr><td>Dmax</td><td>35.865</td><td>47.98</td></tr><tr><td>Dmean</td><td>2.1802</td><td>2.8514</td></tr></table></td>
<td>Prospective LAD contouring and optimization were associated with lower median D mean and D max LAD dose.

Lower median D mean and D max Heart dose in Arm A.</td>
</tr>
<tr>
<td></td>
<td>We contoured LAD retrospectively on already delivered treatment plan.
For differences in the proportion HF versus CF, doses were expressed as an EQD2 (Equivalent Dose).
DVH of both groups were compared.</td>
<td></td>
<td>Lower LAD Dmean in ARM A for both DIBH and FB.

All results are statistically significant (p-value <0.05).</td>
</tr>
</table>

Our study was to compare the doses of LAD artery of retrospectively treated left-sided Breast cancer where LAD artery was neither contoured nor optimized with respect to prospective contouring and optimization.

According to the data, there were 52 patients in total, with 26 patients in each group. Patients with left breast cancer whose heart and LAD were contoured prospectively and optimization were assigned to ARM A (prospective group: 26 patients). ARM B (Retrospective group: 26 patients): Patients who had previously undergone Left Breast irradiation but only had the Heart contoured and optimized, but not the LAD. Heart and LAD dose-volume-histogram (DVH) data from both groups (ARM A, ARM B) were compared. Mean, Maximum doses of LAD and Heart were evaluated and compared between two groups.

On the RT planning CT image, we contoured the LAD immediately distal to its branch-point from the LMCA along the anterior interventricular groove to the apex. Modifications to tangent beam angles, adjustment to the multileaf collimator, and use of the LAD as an optimization parameter during treatment planning were all employed to reduce LAD dose. When optimizing for LAD dose, there was no substantial reduction in target volume coverage.

Comparing the dosimetric values of LAD in both groups, we found that median LAD D max in Arm A vs Arm B: 12.878 Gy vs 39.084 Gy (p-value 0.000000001243), median LAD D mean in Arm A vs Arm B: 4.504 Gy vs 16.711 Gy (p-value 0.00000002858). Comparison between prospective and retrospective groups shows prospective LAD contouring and optimization was associated with lower median D mean and D max LAD dose and were also statistically significant.

Comparing the dosimetric values of the Heart in both groups, we found that median Heart D max in Arm A vs Arm B: 35.865 Gy vs 47.98 Gy (p-value 0.0000004440635), median Heart D mean in Arm A vs Arm B: 2.1802 Gy vs 2.8514 Gy (p-value 0.0197), Comparison between prospective and retrospective groups shows lower median D mean and D max Heart dose in prospective group and were also statistically significant.

Comparing the dosimetric values of LAD Dmean in between two groups separately for DIBH: Arm A vs Arm B: 4.751 Gy vs 11.708 Gy (p-value 0.00002192), and FB: Arm A vs Arm B: 4.363 Gy vs 33.35 Gy (p-value 0.0005828) showed Lower LAD Dmean in case of ARM A.

This shows that, despite identical mean heart doses in all groups, the LAD may be exposed to relatively high doses, and is a persuasive signal to begin contouring the LAD in all situations. Because each patient's anatomy is different, LAD doses may differ from mean heart doses. As a result, both the heart and the LAD artery should be contoured and optimized to reduce the dose as much as possible. The LAD artery, like the heart, should be treated as a vulnerable organ at risk, with doses kept "as low as reasonably achievable."

Thus, improved long-term survival for all stages of breast cancer has prompted an increased focus on long-term toxicities associated with treatment. While population studies and pooled data from older radiotherapy series have demonstrated a potential increase in cardiac morbidity and mortality, there are significant limitations to these data. At the present time, women with left-sided breast cancers should be offered some form of LAD dose sparing technique when feasible. This should be applied both in patients treated with breast-conserving therapy or mastectomy with or without regional nodal irradiation. No particular technique has been found to be significantly superior to any other and multiple options can be applied concurrently; further, it is unlikely that one method will emerge as the dominant cardiac dose sparing technique. This study was to examine the role of prospective LAD artery contouring and avoidance in treatment plans prior to delivery. The result from this study shows that LAD dose sparing was possible with LAD contouring and dose optimization. While attempts should be made to lessen the dose to the heart and LAD artery to minimize cardiac morbidity and mortality.

Conclusion

Our study aimed at evaluating the doses of LAD artery with previously treated left-sided Breast cancer where LAD artery was neither contoured nor optimized with respect to prospective contouring and optimization.

Our results showed that prospective contouring and avoidance of the LAD during treatment planning optimization significantly reduce max and mean LAD dose without compromising planning target volume (PTV) coverage. LAD artery should be contoured and optimized before treatment delivery so as to minimize dose to this structure.

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