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Publisher of open access books and journals
PJMLS OPEN ACCESS
Print ISSN: 2707-4471. Online ISSN: 2707-448X

Original Article	Pak-Euro Journal of Medical and Life Sciences
DOI: 10.31580/ pjmls.v8i1.3207	Copyright © All rights are reserved by Corresponding Author
Vol. 8 No. 1, 2025: pp. 39-44	
www.readersinsight.net/pjmls	**Revised:** March 15, 2025 **Accepted:** March 22, 2025
Submission: January 07, 2025	**Published Online:** March 24, 2025

CROSS SECTIONAL EVALUATION OF THE MEAN HEART DOSES IN BREAST CANCER PATIENTS TREATED WITH THREE-DIMENSIONAL CONFORMAL RADIOTHERAPY AT INMOL CANCER HOSPITAL, LAHORE

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Abstract

This study aimed to determine mean heart doses (MHD) received by breast cancer patients who underwent 3D-CRT treatment at INMOL Cancer Hospital in Lahore. The six-month cross-sectional research took place at INMOL Cancer Hospital, Lahore according to Letter No. INMOL-128, 15-06-2024. The research studied 126 female breast cancer patients who received 3D-CRT treatment at INMOL Cancer Hospital with non-probability purposive sampling. The research team obtained patient data points focused on age alongside surgical procedures along with affected sites from breast cancer patients. The research utilized computed tomography (CT) plans to calculate mean heart doses and carried out statistical evaluations with version 21 of SPSS. The patients had an average age of 43.31 ± 9.29 years. The heart received an average 2.429 ± 2.367 Gy of radiation dose throughout all cases. The patients with left-sided breast tumors received considerably higher mean heart doses amounting to 4.722 ± 0.753 Gy than those with right-sided breast cancers who received 0.136 ± 0.198 Gy with p-value < 0.001. Among patients who received left-sided modified radical mastectomy (LT-MRM) treatment the mean heart dose reached its peak value of 5.207 + 0.547 Gy whereas right-sided breast-conserving surgery (RT-BCS) produced the least amount of heart dose at 0.105 + 0.148 Gy. ANOVA tests showed that surgical methods produce distinct mean heart doses that reach statistical significance (p < 0.001). The mean heart doses between age groups showed no statistical differences based on p = 0.371. Mean heart doses show a major difference between patients diagnosed with left-sided versus right-sided breast cancer when receiving 3D-CRT care since left-sided patients face significantly higher cardiac exposure risks. Radiotherapy planning requires customization to lower the cardiac health risks for patients diagnosed with left-sided breast cancer based on study findings.

Keywords: *3D-CRT, Breast cancer, Radiotherapy planning*

INTRODUCTION

Breast cancer is the most prevalent cancer and leading cause of cancer death among women according to Global cancer statistics 2022, with a total of 2.3 million new cases reported globally (1). According to a cancer report of Pakistan from 1994 to 2021, Punjab is the leading province for the prevalence of cancer cases with the breast cancer being the most common malignancy nationwide (2). Moreover, breast carcinoma incidence in young women has been increasing recently. Mostly, young females are not targeted during screening activities leading to delayed diagnosis in more advanced stages which will lead to adverse clinical outcomes and treatment complications compared to older patients (3, 4).

The treatment for breast cancer is multidisciplinary including locoregional and systemic treatments. Locoregional treatment includes surgical removal and local radiotherapy (5). Radiotherapy (RT) is a vital part of adjuvant treatment for breast cancer, reducing the risk of local recurrence and mortality. However, it also poses a risk to the heart, with evidence supporting a linear relationship between the radiation dose and heart disease, particularly after left-sided RT. This has been linked to increased cardiovascular morbidity and mortality (6, 7). Most epidemiological studies on post-radiotherapy cardiotoxicity focus on the total dose received by the heart, referred to as the MHD. However, the dose distribution within the heart is uneven, with the highest doses often occurring at the apex and in the apical-anterior segment, where doses can exceed 50 Gy (8, 9).

Cardiac dose also depends on which side of the breast is irradiated. A study found that while heart doses from left-tangential radiotherapy have significantly decreased over the past 40 years, about half of left-sided patients still receive doses exceeding 20 Gy in some regions of the heart. In contrast, for right-sided breast cancer, cardiac exposure usually results from scattered radiation (10).

Understanding the relationship between cardiac doses and heart diseases is crucial for oncologists in assessing the radiation-related risks for patients. In Pakistan, however, there is a lack of radiotherapy facilities and insufficient data on mean heart doses for breast cancer patients in local settings. This study was devised to estimate mean heart doses for patients treated with 3D-CRT, which would help in monitoring radiation exposure to the heart during breast cancer treatment.

METHODOLOGY

The research took place at INMOL Cancer Hospital, Lahore during a six-month period from July 2024 to December 2024. The ethical review board of the institution granted ethical approval by letter number INMOL-128, 15-06-2024. A sample of 126 was calculated at 95% confidence level with 80% power of test, and assumed mean heart dose for right sided breast cancer of 0.5±0.1 Gy.8 The histologically proven breast cancer patients aged 18 years or above, having disease up to stage III, and Eastern Cooperative Oncology Group (ECOG) performance status score of 0-2, irradiated with 3D-CRT were recruited through non-probability purposive sampling after informed consent (63 with left sided disease and 63 with right sided disease). Academic researchers did not include patients who had metastasized disease bilaterally or who experienced disease recurrence or who received treatment with palliative intent. All patients received 6-MV photon beam therapy following the completion of contouring delineation and plan evaluations that met guidelines criteria. Without modifying the field borders to reduce cardiac dosage or employing cardiac shielding devices in the procedure. Tumor treatments consisted of 40 Gy isocenter delivery through 15 fractionized doses which ran five times per week. The pencil beam algorithm processed full CT density information although it incorporated lung corrections for dose calculations. The examination of cardiac doses relied on the entire three-dimensional CT dataset because a wide-bore virtual simulator produced five-millimeter slices stretching from the clavicle down to the mid-abdomen. The healthcare professionals extracted information regarding age, clinical presentation, site of involvement, stage and prescribed radiation dose from patient records. Researchers conducted the evaluation using prescribed doses by determining the average whole heart doses across CT planning for each patient which they named mean heart dose. SPSS V. 21 was used (p-value <0.05).

RESULTS

The mean age of 120 breast cancer patients treated with 3D-conformal radiotherapy was 43.31 ± 9.29 years. The mean heart dose for the study participants was calculated to be 2.43 ± 2.37 Gy. When stratified by age groups, the mean heart dose was found to be highest in the 41-50 years age group, with mean of 2.85 ± 2.27 Gy, followed by the 27-40 years group (2.25 ± 2.347 Gy) and the above 50 years group (2.15 ± 2.53 Gy). However, there was no statistically significant difference in mean heart doses among the age groups (p = 0.371) (Table I).

Table I. Stratification of mean heart dose with respect to various age groups

Age groups (years)	Mean heart dose (Gy) (mean±SD)	p-value
27-40	2.25 ± 2.35	0.606
41-50	2.85 ± 2.27	
Above 50	2.15 ± 2.53	

The analysis of mean heart dose between left- and right-sided breast cancer cases revealed a significant disparity. The mean heart dose for left-sided cases was markedly higher at 4.722 ± 0.753 Gy compared to 0.136 ± 0.198 Gy for right-sided cases. This difference was statistically significant with p-value < 0.001 (Table II). Similarly, surgical procedures also influenced heart dose distributions. Patients who underwent left-sided modified radical mastectomy (LT-MRM) had the highest mean heart dose at 5.21±0.55

Gy, while those who underwent right-sided breast conserving surgery (RT-BCS) had the lowest mean heart dose at 0.11 ± 0.15 Gy.

Table II. Mean heart dose on basis of laterality of breast cancer

Breast Cancer Laterality	Mean heart dose (Gy) (mean±SD)	p-value
Right sided breast cancer	0.136 ± 0.198	<0.001
Left sided breast cancer	4.722 ± 0.753	

The statistical analysis revealed significant differences in mean heart doses among the surgical procedure groups with p-value<0.001 (Table III). Moreover, a significant difference was found between MHDs received by patients of left sided modified radical mastectomy (5.21 ± 0.55 Gy) and left sided breast conserving surgery (4.24±0.61Gy) (p-value <0.001).

Table III. Stratification of mean heart dose with respect to type of surgery

Type of surgery	Mean heart dose (Gy) (mean±SD)	p-value
Left-sided modified radical mastectomy	5.21 ± 0.55	<0.001
Right-sided modified radical mastectomy	0.17±0.23	
Left-sided breast conserving surgery	4.24±0.61	
Right-sided breast conserving surgery	0.11 ± 0.15	

DISCUSSION

The findings of this study provide valuable insights into the mean heart doses associated with 3D-CRT for breast cancer patients treated at INMOL Cancer Hospital, Lahore. The mean age of 120 patients included in this study was 43.31 ± 9.29 years. Half of the patients (n=60, 50%) were with left sided breast carcinoma while another half had right sided breast carcinoma. The mean heart dose for the study participants was calculated to be 2.43 ± 2.37 Gy. The mean heart dose calculated for left sided breast carcinoma patients was 4.722 ± 0.753 Gy while it was 0.136 ± 0.198 Gy for patients with right sided breast carcinoma. In contrast to our findings, previous researcher found the mean age of population to be 58 years where 89 patients were left sided and 15 were right sided breast carcinoma (11, 12). The MHD for left sided radiotherapy was 2.95 ± 1.49 Gy, and 0.46 ± 0.12 Gy for right-sided radiotherapy. Similarly, a study conducted in Pakistan included 52 patients with breast carcinoma of left side and 31 patients with breast carcinoma of right side. The MHD for patients with right sided disease was 1.88 Gy while it was 7.07 Gy for patients with left sided disease (13, 14). Both values are higher as compared to our results. Another study reported MHD of 0.87 Gy and 0.41 Gy for left and right sided breast cancer patients respectively (11). Mean heart doses after radiotherapy was reported as 2.1 Gy and 2.3 Gy which are quite similar to our findings (15, 16).

Another study compared MHD of two groups with new and non-new perfusion defects among left breast cancer patients (17). The MHD of new perfusion defect group was 3.14 Gy while it was 3.08 Gy in non-new perfusion defect group (18). A systematic review reported that the MHD for left sided breast cancer patients postradiotherapy was 2 Gy while it was 1 Gy for right sided breast cancer patients (19, 20).

When MHD received by patients with various types of surgery were compared, statistical analysis showed a significant difference among various types in our study (p-value<0.001). Similarly, our findings also showed a significant difference between MHDs of patients who underwent left sided breast conserving surgery and left sided modified radical mastectomy. A researcher found an insignificant difference between MHDs of left sided breast cancer who underwent mastectomy and breast conserving surgery with values of 3.364 Gy and 4.219 Gy respectively (21, 22). Another study conducted at Baghdad Radiotherapy Center; Iraq included 174 breast cancer patients to compare MHDs of patients undergoing breast conserving surgery versus mastectomy. The overall mean heart dose was found to be 3.72 Gy whereas no statistically significant difference was found among MHDs of patients with both types of surgery. However, the MHDs of patients undergoing mastectomy for right and left sided breast cancer were significantly different with p-value<0.001, which is quite similar to our results (23).

A nested case control study was conducted to find the effects of radiotherapy on myocardial infarction rate in breast cancer patients post-radiotherapy. It was found that myocardial infarction rate

increased linearly with increasing MHD. Moreover, the 20-year cumulative risk of myocardial infarction for patients who received no radiotherapy was 0.9% as compared to 4.2% for those who received ≥20 Gy. Also, the use of chemotherapy or presence of previous cardiovascular disease did not show any association with increased risk of myocardial infarction (24).

CONCLUSION

The results indicated that left-sided radiotherapy poses a considerably higher risk of increased heart dose exposure compared to right-sided radiotherapy. The findings also highlight the influence of age and surgical procedure on mean heart doses, emphasizing the need for optimized treatment planning to mitigate potential cardiac risks. Future research is recommended considering large sample size or multicentered study, randomized trials, and/or advanced radiotherapy techniques.

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