RESEARCH ARTICLE

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Effect of DIBH Coaching on Dosimetric Parameters of Heart and Lung Doses in Patients Undergoing Adjuvant Breast Radiotherapy

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Abstract

Introduction: Radiation exposure to the heart in women with left-sided breast cancer can lead to cardiac disease and increased mortality. Several techniques, including deep inspiration breath hold (DIBH), have been used to reduce cardiac exposure during radiotherapy. DIBH coaching prior to radiation planning can further reduce cardiac doses. This study aims to compare heart and lung dosimetric parameters between coached and non-coached patients using the DIBH technique for left-sided breast cancer treatment. **Methods:** All patients with left-sided breast cancer who received adjuvant radiotherapy (RT) using the DIBH were included. The first cohort, designated as the non-coached group, received verbal guidance on the breath hold technique but did not undergo formal coaching. The second cohort involved a comprehensive coaching protocol, which began in January 2022. This protocol, led by a physician, included demonstrations and instructions for performing the DIBH technique in the clinic and encouraged patients to practice at home before and during RT to optimize cardiac protection. **Results:** A total of 40 patients met the inclusion criteria for the study, with a mean age of 45.7 ± 8.38 years. Most patients had IDC and Stage II disease, and radiation was primarily delivered using 3DCRT with 4256 cGy in 16 fractions regimes. In terms of cardiac dose exposure, coached patients had slightly lower mean and maximum point cardiac doses, but these differences were not statistically significant. Coached patients also had a significantly lower mean V17 for left lung volume exposure compared to non-coached patients (18.3 vs. 21.6, $p < 0.05$). **Conclusion:** DIBH coaching and home practice prior to RT planning can further reduce cardiac and lung doses, offering a cost-effective intervention, particularly in resource-limited settings, though further controlled studies with larger sample sizes and longer follow-up are needed to assess its clinical impact.

Keywords: DIBH- Coaching- Patient education- Cardiac doses- Lung doses- Radiation planning

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Introduction

Radiation therapy (RT) is a major component of breast cancer treatment, providing effective tumor control but posing significant risks to adjacent organs, especially the heart. The heart's proximity to the left breast increases the likelihood of cardiac radiation exposure during RT, leading to a higher incidence of cardiovascular diseases (CVD) in long-term survivors.

Studies have consistently shown that postmastectomy irradiated patients face an elevated risk of cardiac morbidity and mortality, with radiation doses to the heart contributing to this burden. A meta-analysis revealed an increased rate of cardiac deaths in irradiated breast cancer patients, emphasizing the need for strategies to reduce heart exposure during RT [1]. Furthermore, research by Darby et al. demonstrated that coronary events increased by 7.4% per Gray (Gy) of radiation, reinforcing the dose-dependent relationship between RT and cardiac risk [2]. Therefore, to improve cardiac outcomes, several techniques have been used such as deep inspiration breath hold (DIBH), respiratory gating, prone positioning, and modern radiation planning techniques (e.g., intensity-modulated RT) [3]. During deep inspiration, the diaphragm moves downward, expanding the lungs and effectively pulling the heart away from the chest wall, thereby reducing radiation exposure to the heart and other surrounding tissues [4]. This technique has shown substantial promise in improving dosimetric outcomes in left-sided breast cancer RT.

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Despite the proven effectiveness of DIBH in reducing cardiac dose, its implementation can be challenging. Consistent and accurate breath-holding is critical for maximizing the technique's benefits. Recent studies suggest that coaching patients to achieve optimal breath hold can improve the accuracy and consistency of DIBH, leading to even greater reductions in cardiac exposure. For instance, Kim et al. found that coached patients had significantly lower cardiac doses compared to non-coached patients [5]. This suggests that patient coaching may be a crucial factor in enhancing the effectiveness of DIBH.

However, despite these findings, there remains a gap in the literature regarding a direct comparison of dosimetric outcomes between coached and non-coached patients using DIBH for left-sided breast cancer RT. Although DIBH itself has been well studied, few studies have specifically evaluated how patient coaching influences the dosimetric results, especially in terms of heart and lung dose reduction. Our study aims to fill this gap by comparing the dosimetric parameters of heart and lung doses in coached and non-coached patients using DIBH during left-sided breast cancer RT.

Materials and Methods

Sample

This study included patients with left-sided breast cancer who received adjuvant radiation therapy (RT) using the deep inspiration breath hold (DIBH) technique, following approval from the ethical review committee at our institution. The patients were divided into two groups: the coached group and the non-coached group.

Patients who did not undergo the DIBH technique were excluded from the study.

Non-Coached Group

Patients in this group did not receive any formal coaching. While they were given verbal guidance on the breath-hold technique during the simulation day, they did not receive any structured or ongoing training to improve their technique. This group served as a baseline for comparison to evaluate the impact of coaching on breath-hold consistency and dosimetric outcomes.

Coached Group

Patients in this group received structured coaching to ensure proper breath-hold technique.

Coaching Protocol

The coaching protocol for the deep inspiration breath hold (DIBH) technique was implemented by a physician in the clinic from January to June 2022. The primary goal was to enhance patients' understanding and execution of the technique to optimize cardiac protection during radiation therapy.

Initial Coaching Session

During the initial Radiation Oncology clinic visit, the physician demonstrated the DIBH technique using online images and videos for visual aid. Patients were then guided to perform the technique in the supine position on the examination couch. They were instructed to hold their breath for at least 10 seconds in the treatment position.

Session Duration

Each coaching session lasted approximately 10-15 minutes, allowing time for demonstration, practice, and addressing any patient questions.

Breath-Hold Practice

Patients were encouraged to practice the breath-hold technique at home for a minimum of 5 days before the simulation and throughout the entire course of radiation therapy. The goal was to ensure that patients could consistently hold their breath for the recommended duration.

Follow-Up and Compliance

During Radiation Oncology department visits, patients were asked about their practice at home, by radiation therapy technologists (RTTs).

Radiation Planning

All booked patients underwent CT-based RT planning using the DIBH technique. Target volume delineation for the breast, chest wall and nodal regions was done by residents based on RTOG guidelines [6]. RT volumes were approved by attending physician and then discussed in departmental daily peer review meeting before RT planning by a clinical medical physicist on the Aria-15 planning system using Eclipse workstation [7].

Dosimetric parameters

The prescribed RT doses were 4005 centi-gray (cGy) in 15 fractions for breast or chest wall alone radiation and 4256 cGy in 16 fractions for breast or chest wall with regional nodal irradiation (RNI) based on published data [8]. The acceptance rate of the DIBH plan was assessed based on several parameters, including the maximum and mean doses, along with the percentage cardiac volume exposures receiving 5 Gy (V5), 10 Gy (V10) and 30 Gy (V30), as well as the percentage left lung volume exposures receiving 17 Gy (V17) and 20 Gy (V20 Gy) from both patient cohorts. These parameters were analyzed using Dose Volume Histograms (DVH), as part of the routine plan evaluation and approval process for radiation treatment plans.

Data analysis

Data analysis and management were performed using Stata V15.0.

Descriptive statistics were reported for quantitative variables as median [IQR] and mean (SD), while categorical variables were described as frequencies and percentages. Univariate analysis for quantitative variables in comparison to coaching was performed using the Mann-Whitney U-test and the two-samples independent T-test where applicable, following evaluation of skew and kurtosis. For categorical variables, χ^2 test of independence and the fisher exact test were used for univariate analysis based on the number of observations.

Results

Patient and treatment related characteristics

A total of 40 patients (20 in coached group and 20 in non-coached group) met the inclusion criteria and were included in the final analysis. The mean age of the cohort was 45.7 ± 8.38 years, with most patients being diagnosed with Infiltrating Ductal Carcinoma (IDC) (90.0%) and Stage II disease (n = 32). Radiation therapy was delivered via 3DCRT (65.0%) with 4256 cGy regimes (67.50%). Most patients were managed surgically via breast conserving surgery (n = 23). Compared with non-coached patients, coached patients were significantly more likely to have received 4256 cGy RT regimes (85.0% vs 50.0%; $p < 0.05$). Other patient factors, including age, diagnosis, stage of disease, surgery and RT technique were not significant between the two cohorts.

The overall patient and treatment related characteristics have been summarized in Table 1.

Cardiac dose exposure

The mean cardiac dose of the overall sample was 3.68 ± 1.65 Gy with a maximum point dose of 34.3 ± 6.85 Gy (Table 2). Compared to non-coached patients, coached patientss had lower mean (3.65 vs 3.72 Gy) and maximum point (33.7 vs 34.8 Gy) cardiac doses, however, these were not statistically significant.

Percentage cardiac and Left lung volume exposure

The median V5, V10, and V30 of the percentage cardiac volume exposures of the overall sample was 12.2 [13.3], 4.95 [4.48], and 0.015[0.75], respectively (Table 2). No significant differences were noted when comparing percentage cardiac volume exposure and the V20 of the percentage lung volume exposure between the coached and non-coached groups. Coached patients were, however, found to have a significantly lower mean V17 (18.3 [5.69] vs 21.6 [5.93]; $p < 0.05$) when comparing percentage lung volume exposures.

Table 1. Patient and Treatment Related Characteristics (n = 40)

Variable	Group*		P-value
	Coached (n = 20)	Non-coached (n = 20)	
Age	44.1 (8.75)	47.3 (7.91)	0.2396
Diagnosis			
IDC	16 (80.0)	20 (100.0)	0.106
ILC	1 (5.0)	0 (0.0)	
Metaplastic Ca	3 (15.0)	0 (0.0)	
Stage			
II	14 (70.0)	18 (90.0)	0.235
III	6 (30.0)	2 (10.0)	
Surgery			
MRM	11 (55.0)	6 (30.0)	0.2
BCS	9 (45.0)	14 (70.0)	
Radiation Technique			
3DCRT	10 (50.0)	16 (80.0)	0.096
IMRT/VMAT	10 (50.0)	4 (20.0)	
Radiation Dose			
4005 cGy	3 (15.0)	10 (50.0)	**0.041**
4256 cGy	17 (85.0)	10 (50.0)	

Key: * Values for age denoted as Mean (Standard Deviation); all other values denoted as Counts. (Percentages). P-values denoted for two-sampled T-test test for quantitative values. P-values denoted for Fisher exact test for categorical values. Significant p-values denoted in bold.

Discussion

Several studies have demonstrated that larger volumes of the heart irradiated are associated with higher cardiac mortality, while increased lung irradiation leads to functional lung damage [9-11]. The DIBH technique is widely accepted and has been reported to reduce both cardiac and lung doses in left-sided breast cancer patients [12, 13]. In a meta-analysis, lower doses to the heart, left anterior descending coronary artery (LADCA) and left lung were found in left-sided breast cancer patients treated with DIBH technique as compared to those treated with free breathing (FB) [14]. However, there is still a lack of standardization in DIBH protocols [15].

Performing DIBH is challenging for patients and may increase their anxiety levels, as the success of DIBH is mainly dependent on patients' ability to hold their breath effectively, which can be improved through patient training and education [16, 17]. There is limited data on patient education regarding radiation planning that incorporates patients' perspectives. Much of the existing literature on patient education lacks detailed descriptions of its design and is typically created solely by radiation oncology healthcare professionals that may not always be easily comprehended by patients [18, 19]. Patient instructions for DIBH are provided on the same day as CT simulation in most of the centers, while only a few institutions initiate patient training and education prior to RT planning procedures [5, 20].

Table 2. Cardiac Dose and Percentage Volume Exposure by Coaching Group (n = 40)

Variable	Group *		P-value
	Coached (n = 20)	Non-coached (n = 20)	
Cardiac dose (Gy) a			
Maximum	33.7 (7.30)	34.8 (6.48)	0.5991
Mean	3.65 (1.36)	3.72 (1.94)	0.9059
Cardiac volume exposed (%) b			
V5	14 [15.2]	9.45 [12.6]	0.3302
V10	4.97 [3.1]	4.23 [7.17]	1
V30	0.006 [0.75]	0.03[0.66]	0.9888
Lung volume exposed (%)			
V17 [a]	18.3 (5.69)	21.6 (5.93)	**0.04**
V20 [b]	16.01 [6.21]	17.65 [10.25]	0.2339

Key: *, Values denoted as Mean (Standard Deviation) or Median [Interquartile Range]. [a], P-values denoted for two-sampled T-test test. [b], P-values denoted for Mann-Whitney U-test of Medians. Significant p-values denoted in bold.

In our study, the results suggest that DIBH coaching and home practice help in reducing cardiac and lung doses. We found that the mean and maximum cardiac doses for coached patients were 3.65 Gy and 33.7 Gy, which were lower than the 3.72 Gy and 34.8 Gy observed in the non-coached group, although the difference was not statistically significant. This finding is consistent with published data showing reduced cardiac doses with patient coaching and education for DIBH [5, 20, 21]. However, the V5 and V10 of the heart were slightly higher in the coached group as compared to the non-coached group i.e.,14% and 4.97% vs 9.45% vs 4.23% (Figure 1). This finding is also not statistically significant and is probably explained by more patients in coached group receiving chest wall RT with RNI and a higher RT dose of 4256 cGy (Table 1). The V30 of the heart was similar between both groups due to the negligible portion of the heart receiving 30 Gy (<0.1%) using DIBH.

Although several studies have reported reduced lung doses using DIBH, but impact of patient coaching in reducing ipsilateral lung volume exposures is unclear [22, 23]. Interestingly, we observed reduced left lung volume exposures in coached patients. The V17 of the left lung was 18.3% in the coached group and 21.6% in the non-coached group, which was statistically significant (p=0.04). This finding contrasts with Kim et al., where no such significant difference in lung doses between the coached and non-coached groups was found [5]. The V20 of the left lung was also reduced in coached vs non-coached group (16% vs 17.3%, not statistically significant).

Despite these findings, our study has several limitations that include small sample size and its non-randomized nature. Factors such as patient characteristics including age, obesity, pre-existing medical conditions may have impacted the results. No formal instruction sheet mentioning home practice plan was provided to patients, therefore compliance with the coaching program could not be assessed. Since patients from both cohorts were able to perform DIBH, it is difficult to ascertain whether the reduced cardiac and lung doses observed in coached group were solely due to coaching or influenced by other factors.

Considering this was a dosimetric analysis, we did not record patient feedback or assess the impact of coaching on other factors such as simulation and treatment time, patient setup variations etc. which may have provided valuable insights.

In conclusion, our study suggests that DIBH coaching and home practice prior to RT planning can further reduce cardiac and lung doses. Coached patients had lower mean cardiac doses (3.65 vs. 3.72 Gy). Additionally, coached patients were found to have a significantly lower mean V17 value (18.3% vs. 21.6%, $p < 0.05$) when comparing percentage lung volume exposures. This no-cost intervention is especially helpful in resource-limited settings where health literacy is a major concern. However, additional controlled studies with larger sample sizes, longer follow-up, and more in-depth dosimetric analyses are required to fully assess the clinical impact of DIBH coaching.

Author Contribution Statement

Laraib Khan: Manuscript writing, Data Collection. Maham Khan: Manuscript writing. Fabiha Shakeel: Drafting. Tooba Ali: Data Collection. Mariam Hina: Manuscript writing. Aahan Arif: Data Analysis. Firza Rahim Sarfaraz: Data Collection. Maria Tariq: Review. Asim Hafiz: Review. Bilal Mazhar Qureshi: Review. Ahmed Nadeem Abbasi: Review. Nasir Ali: Conceptualization.

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None.

Conflict of interest

The author(s) declare that they have no conflict of interest.

The study was conducted after institutional Ethics Review Committee (ERC)

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