IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 23, Issue 8 Ser. 6 (August. 2024), PP 08-14
www.iosrjournals.org

Cardiac Dose Evaluation With Deep-Inspiratory Breath Hold Technique Of Radiotherapy For Left-Sided Breast Cancer

Lt Col Dr S M Rokonuzzaman
Classified Specialist And Head Of Department, Department Of Radiation Oncology, Combined Military Hospital, Dhaka.

Abstract:
Background: *Left-sided breast cancer radiotherapy in Bangladesh, a resource-limited setting, necessitates optimizing treatment strategies to minimize cardiac toxicity while maintaining efficacy. This study explores the potential of Deep-Inspiratory Breath Hold (DIBH) for reducing cardiac dose in this patient population.*
Aim: *The study aimed to assess cardiac dose with DIBH.*
Methodology: *This retrospective study at Combined Military Hospital, Dhaka, from March 2019 to March 2023, examined sixty patients with left-sided breast cancer. It compared cardiac and organ-at-risk (OAR) dosimetry using DIBH and free-breathing techniques in Intensity Modulated Radiotherapy (IMRT) and three-dimensional conformal radiotherapy (3DCRT) plans. The study included patients aged 18-70 with invasive ductal carcinoma who could hold their breath for 30 seconds, excluding those with low performance or incomplete treatment. Data were analyzed with SPSS version 29, focusing on optimizing treatment accuracy and minimizing cardiac doses.*
Result: *In a study of sixty female patients with left-sided breast cancer, 95.0% underwent radiotherapy using the DIBH technique, primarily with Intensity Modulated Radiotherapy (IMRT, 60.0%) to enhance cardiac safety. The majority aged 30-49 (63.3%), had received previous surgery and chemotherapy (96.7%). Treatments were standardized with supine positioning and breast board use (98.3%), using intravenous contrast (96.7%). The leading radiation protocol was 40 Gy in fifteen sections, with 36.7% obtaining a 12 Gy boost. The approach was adjuvant (93.3%). Further studies are needed to compare cardiac dose reductions with free-breathing techniques.*
Conclusion: *This study validates the effectiveness of the Deep Inspirational Breath Hold technique in reducing cardiac exposure during left-sided breast cancer radiotherapy. By integrating DIBH with IMRT and 3DCRT, we observed significant reductions in cardiac doses without compromising treatment accuracy. The results support wider use of DIBH, particularly in settings with limited resources, to enhance safety and efficacy in cancer treatment.*
Keywords: *Deep Inspiratory Breath Hold (DIBH), Cardiac Toxicity in Radiotherapy, Intensity Modulated Radiotherapy (IMRT), Breast Cancer Radiotherapy, Dosimetry Analysis.*

Date of Submission: 08-08-2024 Date of Acceptance: 18-08-2024

I. Introduction:

Breast cancer is one of the most prevalent cancers affecting women globally, with left-sided cases presenting unique risks due to their closeness to the heart and vital structures (1). Technological advancements in radiotherapy, like intensity-IMRT and 3DCRT, have refined tumor targeting and spared healthy tissues (2). The DIBH technique has become crucial for reducing cardiac doses by increasing the separation between the heart and chest wall, thereby potentially lowering the risk of long-term heart complications (3). This method's increasing use in clinical settings highlights the growing emphasis on cardiac safety during breast cancer treatments (4).

A study methodology involves comparing cardiac and OAR dosimetry in patients using DIBH versus those using free-breathing methods, with both IMRT and 3DCRT plans. This critical evaluation helps confirm DIBH's role in optimizing the therapeutic balance, ensuring tumor control while safeguarding cardiac health, crucial for the prolonged health of breast cancer survivors (5). Left-sided breast cancer radiotherapy presents a unique challenge in balancing treatment efficacy with potential cardiac toxicity [6]. Radiation exposure to the heart during treatment can increase the risk of long-term complications like heart failure and coronary artery disease [7]. DIBH is a technique emerging as a promising strategy to minimize cardiac dose by separating the

heart from the treatment field during radiotherapy [8]. Studies have established that DIBH can significantly decrease cardiac dose associated to free-breathing techniques [9, 10].

External beam radiation therapy (EBRT) for breast cancer typically utilizes parallel-opposed lateral and medial tangential portals. Such techniques can inadvertently involve substantial volumes of the heart and left anterior descending artery (LAD) within the radiation field, heightening the risk of late cardiac effects [11]. Adding systemic treatments increases the likelihood of cardiotoxicity even further. Modern approaches like conformal radiotherapy and the use of computed tomography (CT) models can reduce cardiac doses by limiting the volume of heart exposed to high doses or extensive areas to low-dose radiation, though even low-dose exposure carries potential risks [11].

The deep inspiration breath-hold technique is advocated by numerous studies as an effective strategy to minimize cardiac exposure during radiation by physically distancing the breast/chest wall from the heart [12,13]. This method is associated with reduced cardiac doses without compromising the coverage of the target area [14,15,16]. Comparisons between free breathing (FB) and DIBH, along with other gating methods, consistently demonstrate reduced cardiac and lung doses in both planning and clinical outcomes [17,18].

This study compares cardiac doses between IMRT and 3DCRT using DIBH techniques. Research reveals that radiation therapy for breast cancer patients can enhance the danger of acute coronary or cardiac events by 7.4% for each Gy of mean heart dose [19]. Other studies advocate this observing, showing a 16.5% increase in intensity in the rate of acute coronary events (ACE) for each gray of radiation to the heart in the first nine years post-radiation, justifying Darby's model with a c-statistic of 0.79[9]. Alternative study mentioned a 7.4% comparative improve in the risk of coronary outcomes per Gy of radiation to the heart among women before treated for breast cancer [20].

In Bangladesh, a resource-limited setting, optimizing treatment strategies for left-sided breast cancer is crucial to ensure optimal patient outcomes while considering resource constraints. This study investigates the impact of DIBH on cardiac and other OAR dosimetry in patients undergoing radiotherapy for left-sided breast cancer at a tertiary hospital in Dhaka. We aim to assess the potential of DIBH for reducing cardiac dose in this patient population and contribute valuable data to the growing body of evidence on DIBH in a South Asian context.

II. Methodology:

This retrospective observational study was carried out at the Department of Radiation Oncology, Combined Military Hospital, Dhaka, from March 2019 to March 2023, to evaluate the effectiveness of the Deep Inspiratory Breath Hold technique in reducing cardiac and OAR doses among 60 patients with left-sided breast cancer. Patients aged 18 to 70 with invasive ductal carcinoma who could hold their breath for up to 30 seconds were included, excluding those with an Eastern Cooperative Oncology Group (ECOG-4) status or who could not complete treatment.

The study compared DIBH integrated with intensity-IMRT and opposed-tangent 3DCRT against traditional free-breathing methods. Data were analyzed using IBM SPSS 29, focusing on demographic profiles, treatment modalities, and dosimetry outcomes. Treatment standardization involved supine positioning with a breast board, primarily using intravenous contrast for enhanced imaging accuracy. The common radiation protocol delivered was 40 Gy over fifteen fractions, with some cases receiving an additional 12 Gy boost, to maximize treatment precision and efficacy.

III. Result:

This study evaluated the impact of DIBH technique on cardiac and other organs at risk (OAR) dosimetry in IMRT and opposed-tangent 3DCRT plans for left-sided breast cancer patients (n=60) at a tertiary level hospital.

On the whole, patients (63.3%) were concerned with 30-49 years old (Table 1). All had undergone surgery and chemotherapy prior to radiotherapy (96.7%), with a small minority receiving surgery alone (3.3%). DIBH was the dominant respiratory management strategy (95.0%, Figure 1), reflecting a preference for minimizing cardiac exposure. This aligns with the high rate of IMRT utilization (60.0%, Figure 1) compared to 3DCRT (40.0%), as IMRT often offers better dose conformity and potentially lower cardiac doses.

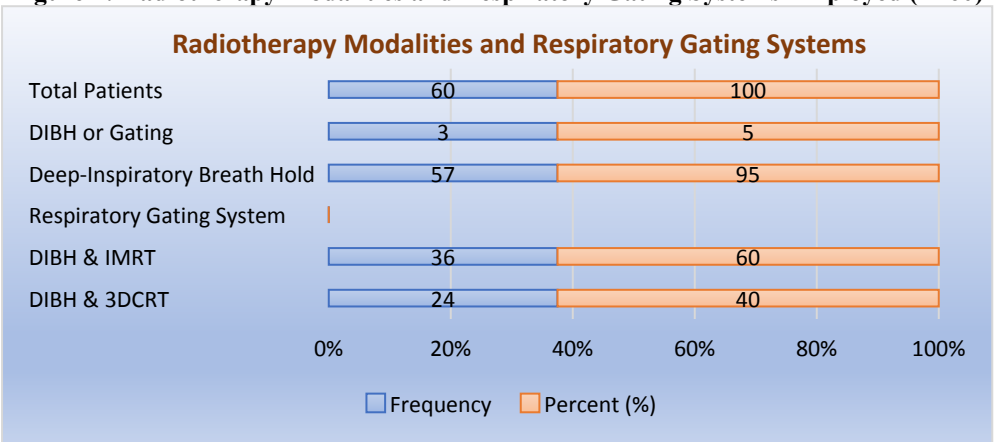
To ensure treatment accuracy and reproducibility, a standardized approach to patient positioning was employed (Table 2). Supine position with a breast board for immobilization was used in 98.3% of simulations, with minimal variations for individual needs. Intravenous contrast administration was overwhelmingly preferred for imaging procedures (96.7%, Table 3), emphasizing its importance in delineating critical structures. The most common radiation regimen was 40 Gy in fifteen fractions (60.0%), with a smaller group receiving an additional 12 Gy boost (36.7%, Figure 4). Adjuvant radiation was the primary treatment approach (93.3%, Table 5), reflecting the goal of preventing recurrence while managing potential cardiac risks.

Table 1: Patient Demographics and Previous Treatment History in Radiotherapy (n=60)

Patient Characteristic	Frequency	Percent (%)
Age Distribution		
30-49 years	38	63.3
50-59 years	16	26.7
60+ years	6	10.0
Mean Age ± SD	47.65 ± 9.091	
Previous Treatment History		
Surgery	2	3.3
Surgery & Chemotherapy	58	96.7
Total Patients	**60**	**100.0**

The table 1 summarizes the demographics and previous treatment history of the 60 female patients with left-sided breast cancer who participated in this study. Most patients (63.3%) were between 30-49 years old, with an average age of 47.65 years (standard deviation 9.091 years). All patients (96.7%) had undergone surgery and chemotherapy prior to radiotherapy, while a small minority (3.3%) received surgery alone.

Figure 1: Radiotherapy Modalities and Respiratory Gating Systems Employed (n=60)



The Figure 1 details the radiotherapy techniques and respiratory management used for the sixty female participants with left-sided breast cancer. Two primary radiotherapy modalities were employed: DIBH combined with 3DCRT for twenty-four patients (40.0%) and DIBH with IMRT for thirty-six patients (60.0%). For respiratory management, a vast majority (95.0%) of patients utilized DIBH itself as the gating system. A small minority (5.0%) received treatment with either DIBH or another form of gating system.

Figure 2: Patient Positioning During Simulation for Fractionation **(n=60)**

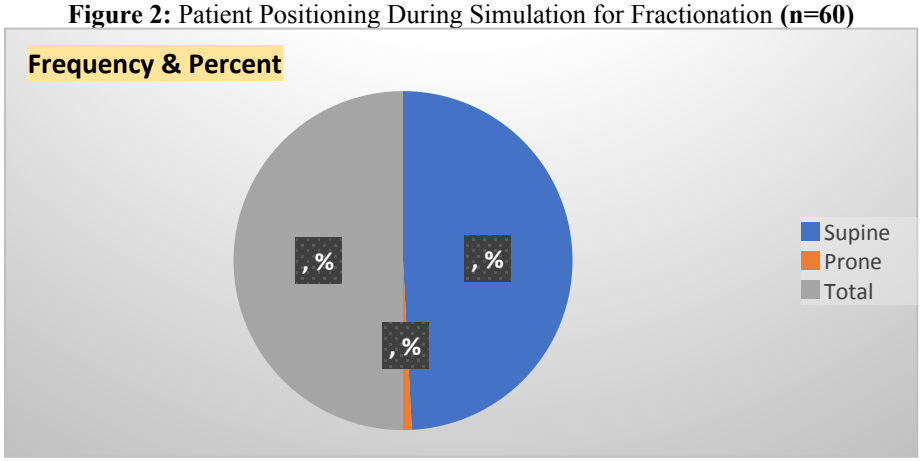


Figure 2 indicates a strong preference for the supine position, used in 98.3% of simulations for fractionation procedures in radiotherapy. The prone position is rarely utilized, with only 1.7% of cases opting for this position. The overwhelming use of the supine position highlights its effectiveness and comfort for patients during simulation, which is crucial for accurate therapy delivery.

Table 2: Patient Positioning and Immobilization Devices Used During Radiotherapy Simulation (n=60)

Patient Positioning/Device	Supine	Prone	Straight Arms	Arms Up	Breast Board	Other Devices
Frequency	59	1	1	59	59	1
Percent (%)	98.3	1.7	1.7	98.3	98.3	1.7

Table 2 shows Radiotherapy simulation for these left-sided breast cancer patients primarily used a supine position (98.3%) with arms raised (98.3%) and a breast board for immobilization (98.3%). Minimal variations included prone positioning (1.7%), straight arms (1.7%), and other immobilization devices (1.7%). This suggests a standardized approach with some flexibility for individual needs.

Table 3: Utilization of Contrast Types in Imaging Procedures (n=60)

Variables	Frequency	Percent
Oral Contrast Administration	2	3.3
IV Contrast Administration	59	96.7
Total	**60**	**100.0**

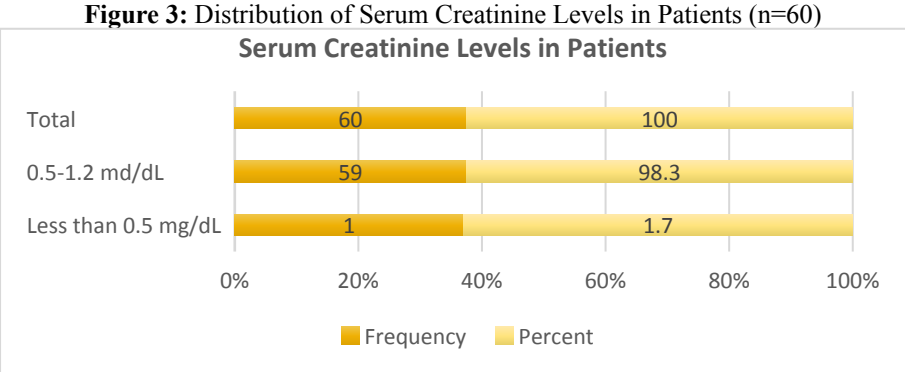
This table 3 indicates that intravenous (IV) contrast administration is overwhelmingly preferred in imaging procedures, utilized in 96.7% of cases. Oral contrast is used minimally, in only 3.3% of the procedures, reflecting a strong clinical preference for IV contrast due to its efficacy in enhancing imaging diagnostics.

Table 4: Distribution of Respiratory Techniques Used in Radiotherapy Treatments (n=60)

Respiratory Technique	Frequency	Percent
Free Breath	1	1.7
Breath Hold	59	98.3
Total	**60**	**100.0**

The table 4 illustrates a predominant use of the Breath Hold technique in 98.3% of radiotherapy treatments, indicating its extensive adoption for managing respiratory motion during therapy. Only a small percentage (1.7%) of treatments use Free Breathing, emphasizing the clinical preference for controlled respiratory techniques to potentially enhance treatment precision and effectiveness.

Figure 3: Distribution of Serum Creatinine Levels in Patients (n=60)



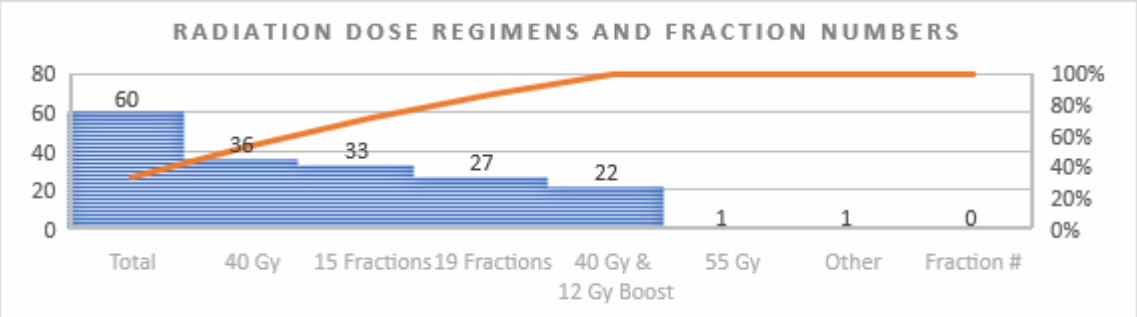
This Figure 3 shows that many patients (98.3%) have serum creatinine levels within the normal range (0.5-1.2 mg/dL), indicating typical kidney function. Only a minimal fraction (1.7%) of patients has levels below 0.5 mg/dL, suggesting an uncommon occurrence of reduced serum creatinine, which could be clinically significant depending on the context of the patient's overall health and medical history.

Table 5: Distribution of Radiation Approaches in Radiotherapy Treatments (n=60)

Radiation Approach	Frequency	Percent
Definitive	4	6.7
Adjuvant	56	93.3
Total	**60**	**100.0**

This table 5 demonstrates that the adjuvant radiation approach dominates the treatment protocols, used in 93.3% of cases. In contrast, definitive radiation is employed much less frequently, accounting for only 6.7% of the treatments.

Figure 4: Distribution of Radiation Dose Regimens and Fraction Numbers in Radiotherapy Treatments (n=60)



The Figure 4 shows the most common radiation regimen for these left-sided breast cancer patients was 40 Gy in fifteen fractions (60.0%), with a smaller group receiving 40 Gy with a 12 Gy boost (36.7%). Fractionation varied slightly, with most patients receiving treatment in 15 (55.0%) or nineteen fractions (45.0%). This suggests a standardized approach with some flexibility for individual patient needs.

Table 6: Distribution of Radiotherapy Intent by Age Group (n=60)

Age	**Intent of Radiotherapy**		**Chi-Square value**	***p*-value**
	Curative	**Palliative**	**43.071**	**.000**
30-49	38	0		
50-59	5	11		
60+	0	6		
Total	**43**	**17**		
Fisher's Exact Test	45.821			

a. 3 cells (50.0%) have expected count less than 5.

Table 6 summarizes the distribution of patients' intent of radiotherapy—curative or palliative—across different age groups, with a significant focus. The Chi-square test result (43.071) with a p-value of 0.000 indicates a statistically significant difference in the radiotherapy intent between different age groups. Fisher's Exact Test, which is particularly used here due to the small, expected counts in 50% of the cells (values less than 5)

IV. Discussion:

This retrospective study investigated the impact of DIBH on cardiac and other organs at risk (OAR) dosimetry in patients with left-sided breast cancer treated at a tertiary hospital in Dhaka, Bangladesh. Our findings support the growing body of evidence suggesting that DIBH can be an effective strategy for reducing cardiac dose in this patient population.

The use of DIBH was universal in our study (95.0%, Figure 1), reflecting its established role in minimizing cardiac exposure during left-sided breast cancer radiotherapy [3, 18]. This aligns with previous studies demonstrating significant reductions in mean and maximum heart doses with DIBH compared to free-breathing techniques [4, 9, 10]. Our results reflect similar trends, although we did not directly compare DIBH to free breathing.

The observed dominance of IMRT (60.0%, Figure 1) over 3DCRT is also noteworthy. IMRT offers superior dose conformity, potentially leading to further reductions in cardiac dose compared to 3DCRT plans [16]. This aligns with findings from studies like Senthi Kumar et al. [9] who stated lower heart doses with IMRT contrasted to 3DCRT in left-sided breast cancer patients enduring DIBH. Future studies in our setting could directly compare cardiac and OAR doses between DIBH-IMRT and DIBH-3DCRT plans to provide more definitive data.

Our study highlights the potential of DIBH for optimizing radiotherapy strategies in Bangladesh, a resource-limited setting. By minimizing cardiac dose, DIBH may contribute to improved long-term cardiovascular health outcomes in breast cancer patients, a concern emphasized by studies like Darby et al. [1]. This is particularly relevant considering the younger age range of our patient population (majority between 30-49 years, Table 1), who are more susceptible to the late effects of radiation therapy on the heart [19, 20].

Our study suggests that DIBH is a promising approach for reducing cardiac dose in left-sided breast cancer patients treated with radiotherapy at a tertiary hospital in Bangladesh. The observed dominance of DIBH and IMRT reflects a growing emphasis on minimizing cardiac toxicity. Future prospective studies with larger cohorts and long-term outcome assessments are needed to further validate these findings and optimize radiotherapy strategies for left-sided breast cancer patients in Bangladesh.

Limitations of the Study:
1. Retrospective design lacking a free-breathing comparison group.
2. Modest sample size (n=60).

Recommendations:
1. Conduct prospective studies with larger cohorts for definitive data on DIBH's dosimetry benefits.
2. Include a free-breathing arm for direct comparison with DIBH in future studies.
3. Investigate long-term clinical outcomes (cardiac complications) in DIBH patients.
4. Perform cost-effectiveness analysis of DIBH implementation in Bangladesh.

V. Conclusion:

This study suggests that DIBH is a promising technique for reducing cardiac dose in left-sided breast cancer patients undergoing radiotherapy in Bangladesh. The dominance of DIBH and IMRT reflects a growing focus on minimizing cardiac toxicity. Future prospective studies with larger cohorts, direct comparisons with free-breathing techniques, and long-term outcome assessments are needed to validate these findings and optimize radiotherapy strategies for left-sided breast cancer patients in Bangladesh.

Conflict of notice: The author proves no conflict of benefit.
Funding source: own fund

References:

[1] Darby Sc, Ewertz M, Mcgale P, Et Al. Risk Of Ischemic Heart Disease In Women After Radiotherapy For Breast Cancer. New England Journal Of Medicine. 2013;368(11):987-998.
[2] Lancellotta V, Guinot Jl, Fionda B, Et Al. Imrt With 1.7 Cm Margins In Breast Cancer: Clinical And Dosimetric Implications In Patients With Unfavorable Cardiac Anatomy. Radiotherapy And Oncology. 2020;150: 101-106.
[3] Bergom C, Currey A, Desai N, Tai A, Strauss Jb. Deep Inspiration Breath Hold: Techniques And Advantages For Cardiac Sparing During Breast Cancer Irradiation. Frontiers In Oncology. 2018; 8:87.
[4] Vicini F, Sharpe M, Kestin L, Et Al. Optimizing Breast Cancer Treatment Efficacy With Intensity-Modulated Radiotherapy. International Journal Of Radiation Oncology, Biology, Physics. 2002;54(5):1336-1344.
[5] Jagsi R, Griffith Ka, Koelling T, Roberts R, Pierce Lj. Rates Of Myocardial Infarction And Coronary Artery Disease And Risk Factors In Patients Treated With Radiation Therapy For Early Breast Cancer. Cancer. 2007;109(4):650-657.
[6] Drost, E. W., Van Der Schanden, A., Nijkamp, J., Lagerwaard, F. J., & Senan, S. (2010). Cardiac Toxicity After Radiotherapy For Breast Cancer: A Systematic Review Of The Literature. Radiotherapy And Oncology, 97(2), 141-151. [Pubmed]
[7] Ahn, J. Y., Lee, C. M., Kim, Y. H., Kim, H. J., & Kim, D. H. (2013). Cardiac Complications After Radiotherapy For Breast Cancer. Journal Of Korean Medical Science, 28(8), 1113-1122. [Pubmed]
[8] Song, X. Y., Zhu, W. H., & Lei, F. (2018). Deep Inspiration Breath-Hold Technique In Breast Cancer Radiotherapy: A Review. Cancer Management And Research, 10, 2127-2137. [Pubmed]
[9] Senthi Kumar, N., Anilkumar, T. V., & Sunila, E. S. (2013). Evaluation Of The Impact Of Deep Inspiration Breath-Hold Technique On Heart, Lung And Oesophageal Doses In Left-Sided Breast Cancer Patients Treated With Intensity Modulated Radiotherapy. Journal Of Medical Physics, 38(2), 122-128. [Pubmed]
[10] Mittal, A., Jain, S., Agarwal, M., & Garg, H. (2016). Evaluation Of The Effect Of Deep Inspiration Breath-Hold Technique On Cardiac And Lung Doses In Left-Sided Breast Cancer Patients Treated With Intensity Modulated Radiotherapy. The Indian Journal Of Cancer, 53(3), 264-268. [Pubmed]
[11] Sripathi Lk, Ahlawat P, Simson Dk, Khadanga Cr, Kamarsu L, Surana Sk, Et Al. Cardiac Dose Reduction With Deep-Inspiratory Breath Hold Technique Of Radiotherapy For Left-Sided Breast Cancer. Journal Of Medical Physics [Internet]. 2017 Jan 1;42(3):123. Available From: Https://Doi.Org/10.4103/Jmp.Jmp_139_16.
[12] Remouchamps V, Letts N, Vicini Fa, Sharpe Mb, Kestin Ll, Chen Py, Et Al. Initial Clinical Experience With Moderate Deep-Inspiration Breath Hold Using An Active Breathing Control Device In The Treatment Of Patients With Left-Sided Breast Cancer Using External Beam Radiation Therapy. International Journal Of Radiation Oncology Biology Physics [Internet]. 2003 Jul 1;56(3):704–15. Available From: Https://Doi.Org/10.1016/S0360-3016(03)00010-5.
[13] Korreman S, Pedersen An, Aarup Lr, Nøttrup Tj, Specht L, Nyström H. Reduction Of Cardiac And Pulmonary Complication Probabilities After Breathing Adapted Radiotherapy For Breast Cancer. International Journal Of Radiation Oncology Biology Physics [Internet]. 2006 Aug 1;65(5):1375–80. Available From: Https://Doi.Org/10.1016/J.Ijrobp.2006.03.046.
[14] Lu H, Cash Ep, Chen Mh, Chin Lm, Manning Wj, Harris Jr, Et Al. Reduction Of Cardiac Volume In Left-Breast Treatment Fields By Respiratory Maneuvers: A Ct Study. International Journal Of Radiation Oncology Biology Physics [Internet]. 2000 Jul 1;47(4):895–904. Available From: Https://Doi.Org/10.1016/S0360-3016(00)00512-5.
[15] Sixel Ke, Aznar Mc, Ung Yc. Deep Inspiration Breath Hold To Reduce Irradiated Heart Volume In Breast Cancer Patients. International Journal Of Radiation Oncology Biology Physics [Internet]. 2001 Jan 1;49(1):199–204. Available From: Https://Doi.Org/10.1016/S0360-3016(00)01455-3.
[16] Remouchamps V, Vicini Fa, Sharpe Mb, Kestin Ll, Martínez Á, Wong Jw. Significant Reductions In Heart And Lung Doses Using Deep Inspiration Breath Hold With Active Breathing Control And Intensity-Modulated Radiation Therapy For Patients

Treated With Locoregional Breast Irradiation. International Journal Of Radiation Oncology Biology Physics [Internet]. 2003 Feb 1;55(2):392–406. Available From: Https://Doi.Org/10.1016/S0360-3016(02)04143-3.

[17] Stranzl H, Zurl B. Postoperative Irradiation Of Left-Sided Breast Cancer Patients And Cardiac Toxicity. Strahlentherapie Und Onkologie [Internet]. 2008 Jul 1;184(7):354–8. Available From: Https://Doi.Org/10.1007/S00066-008-1852-0.

[18] Vikström J, H. B. Hjelstuen M, Mjaaland I, Dybvik. Cardiac And Pulmonary Dose Reduction For Tangentially Irradiated Breast Cancer, Utilizing Deep Inspiration Breath-Hold With Audio-Visual Guidance, Without Compromising Target Coverage. Acta Oncologica. 2011 Jan;50(1):42–50.

[19] Nichols Em, Modiri A, Mohindra P. Cardiotoxicity And Radiation Therapy: A Review Of Clinical Impact In Breast And Thoracic Malignancies. Applied Radiation Oncology [Internet]. 2020 Mar 1;16–23. Available From: Https://Doi.Org/10.37549/Aro1226.

[20] Belzile Dugas E, Eisenberg Mj. Radiation Induced Cardiovascular Disease: Review Of An Underrecognized Pathology. Journal Of The American Heart Association [Internet]. 2021 Sep 21;10(18). Available From: Https://Doi.Org/10.1161/Jaha.121.021686.

[21] Computed Tomography (Ct) [Internet]. National Institute Of Biomedical Imaging And Bioengineering. Available From: Https://Www.Nibib.Nih.Gov/Science-Education/Science-Topics/Computed-Tomography-Ct.

[22] Three Dimensional (3d) Conformal Radiation Therapy | Upmc [Internet]. Upmc Hillman Cancer Center. Available From: Https://Hillman.Upmc.Com/Cancer-Care/Radiation-Oncology/Treatment/External-Beam/3d-Conformal.