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Comparative Study of Heart and Lung Doses in Left-Sided Breast Cancer Radiotherapy with and Without Active Breath Control (ABC)

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Abstract

Background: In left-sided breast cancer radiotherapy, minimizing cardiac and pulmonary exposure is crucial to reducing long-term treatment-related complications. Active Breath Control (ABC) has been proposed as an effective technique to achieve this reduction.

Objective: To compare the heart and lung radiation doses in patients undergoing left-sided breast cancer radiotherapy with and without the use of Active Breath Control (ABC).

Methods: A comparative study was conducted on 30 patients with left-sided breast cancer. Statistical analysis was performed using SPSS version 20.0. Descriptive data were summarized as frequency, percentage, mean, and standard deviation. Paired t-tests were used to compare dosimetric parameters between treatment plans

with and without ABC, with a p-value <0.05 considered statistically significant.

Results: The mean age of the patients was 48.4 ± 10.04 years. Most patients (60%) were aged between 34–53 years. With ABC, 90% of patients had a Planning Target Volume (PTV) margin of 5 mm, while without ABC, all patients had a PTV margin of 7 mm. The mean heart volume was significantly reduced with ABC (11.07 ± 4.44) compared to without ABC (12.82 ± 4.68; $p < 0.001$). Similarly, the left lung volume was significantly lower with ABC (22.78 ± 3.05) compared to without ABC (26.81 ± 3.83; $p < 0.001$). For the right lung, a statistically significant reduction was also observed (0.00 ± 0.00 with ABC vs. 0.30 ± 0.65 without ABC; $p = 0.017$).

Conclusion: The use of Active Breath Control in left-sided breast cancer radiotherapy significantly reduces heart and lung doses. Incorporating ABC in treatment protocols may potentially lower the risk of radiation-induced cardiopulmonary toxicity, thereby improving patient outcomes.

Keywords: Left-sided breast cancer, radiotherapy, Active Breath Control (ABC), heart dose, lung dose, radiation toxicity.

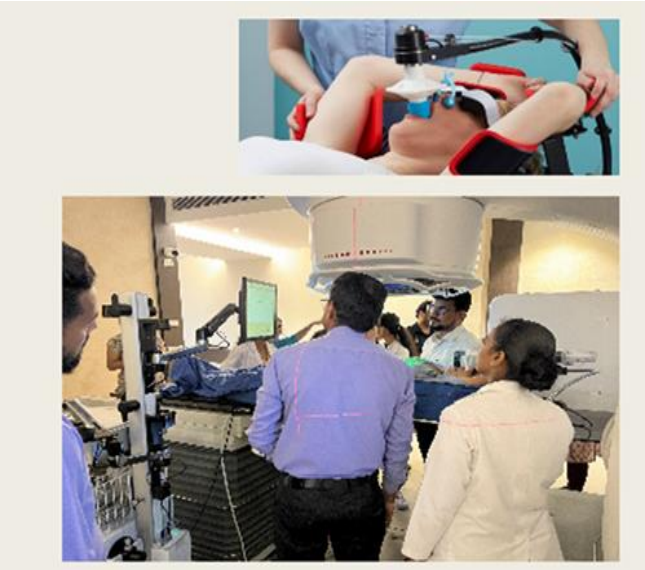
Introduction

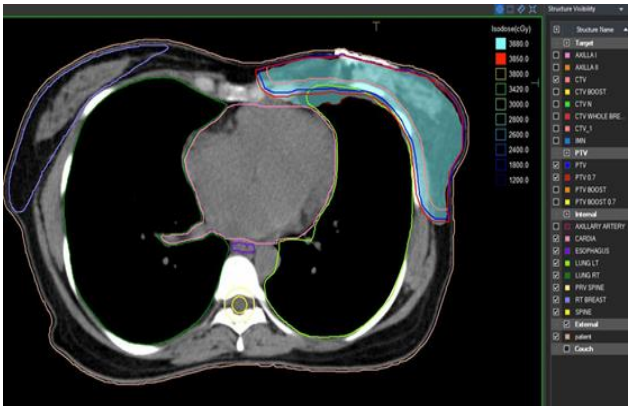
Radiation therapy for breast cancer significantly improves local control and survival rates; however, concerns remain about its associated toxicities, particularly cardiac complications[1,2]. Studies have shown that patients treated for left-sided breast cancer face an increased risk of cardiac mortality, with the mean heart radiation dose closely linked to rates of cardiac deaths and coronary events[3]. The risk is estimated to rise by 4–7% for every additional 1 Gy to the heart, without evidence of a safe lower threshold. Factors like baseline cardiac health and cardiotoxic chemotherapy also influence this risk. As regional nodal irradiation, including the internal mammary chain (IMC), gains importance, minimizing cardiac exposure becomes even more critical[4].

Advances since the pre-three-dimensional radiation era, such as prone positioning and proton therapy, have reduced heart doses[5]. Although intensity-modulated radiation therapy (IMRT) lowers high-dose exposure areas, it may increase low-dose spread. Deep inspiration breath holds (DIBH) has emerged as a valuable technique, utilizing lung expansion during deep breaths to displace the heart from the chest wall, thereby lowering cardiac doses. DIBH can be used alone or combined with prone positioning to optimize heart sparing during treatment, offering a promising approach to reduce long-term cardiac toxicity in breast cancer radiotherapy[6].

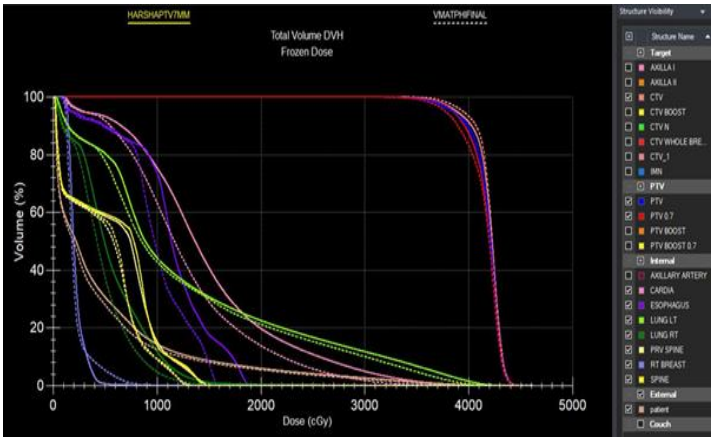
Methods: A comparative study was conducted on 30 patients with left-sided breast cancer undergoing radiation therapy. CECT simulation was done in vaclok mould with ABC apparatus in inspiratory phase. CTV Chest wall and Nodal stations with OAR's contoured according to RTOG guidelines. Individual IMRT planning and dose calculation was performed on MONACO treatment planning system with patient received 50Gy in 25 fractions for 5 weeks.

PTV margins of 7mm, 5mm or 3mm were taken and dose to the OAR's calculated (CARDIA, LUNG). Statistical analysis was performed using SPSS version 20.0. Descriptive data were summarized as frequency, percentage, mean, and standard deviation. Paired t-tests were used to compare dosimetric parameters between treatment plans with and without ABC, with a p-value <0.05 considered statistically significant.





Target and OAR's delineation with Dose distribution.



DVH comparing dose to OAR's with different PTV margins(7mm,5mm/3mm)

Results

Statistical analysis

Statistical analysis of the data was performed using SPSS20.0(IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp). Descriptive statistics were presented using frequency, percentage, mean and standard deviation. Comparison between with ABC and without ABC was done using paired t test. A p value <0.05 will be considered statistically significant.

Table 1: Base line data

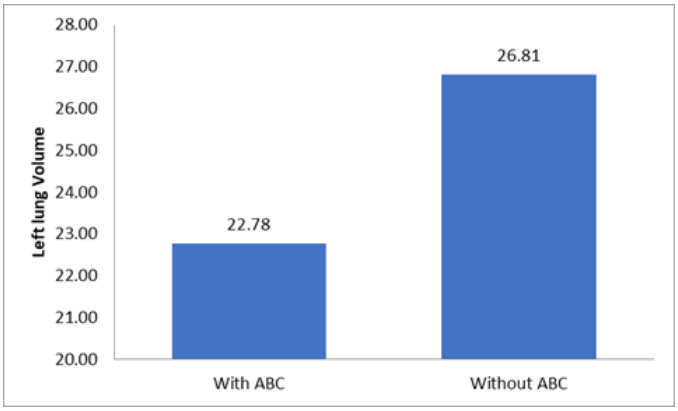
Base line data	Category	Frequency	Percent
Age	24-33 years	2	6.6
	34-53 years	18	60
	54-63 years	10	33.4
PTV margin (With ABC)	3mm	3	10.0
	5mm	27	90.0
PTV margin (Without ABC)	7mm	30	100.0

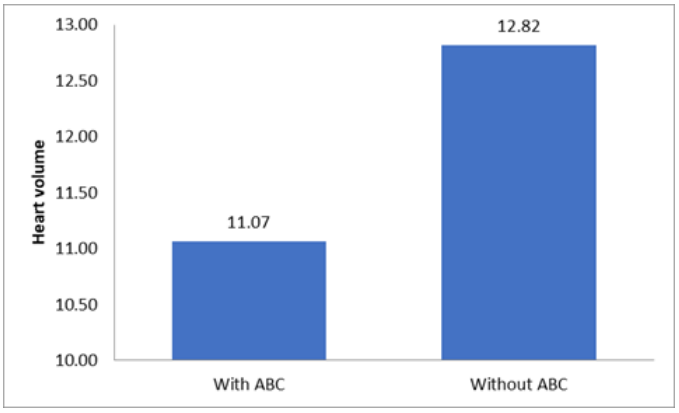
The baseline data showed that the majority of patients (60%) were between 34–53 years of age, while 33.4% were between 54–63 years, and 6.6% were between 24–33 years. Average age is 48.4±10.04 years. Regarding the PTV margin with ABC, 90% of patients had a margin of 5 mm, whereas 10% had a margin of 3 mm. For the PTV margin without ABC, all patients (100%) had a margin of 7 mm.

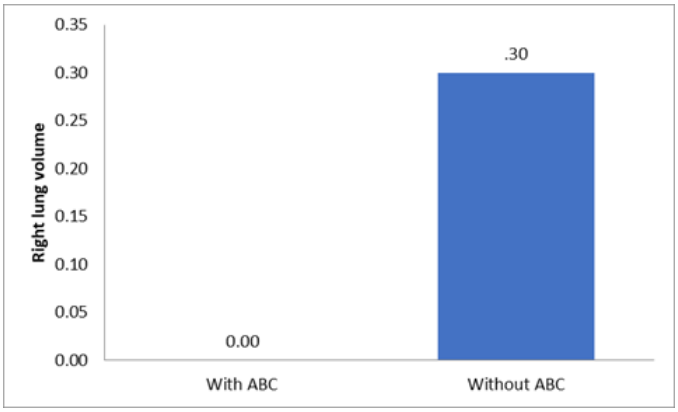
Table 2: Comparison of heart volume, left lung volume and right lung volume between with ABC and without ABC

		Mean	Std. Deviation	t value	p value
Heart Volume	With ABC	11.07	4.43997	5.944	p<0.001
	Without ABC	12.82	4.68210		
Left Lung Volume	With ABC	22.78	3.053	8.969	p<0.001
	Without ABC	26.81	3.829		
Right Lung Volume	With ABC	0.00	0.000	2.523	0.017
	Without ABC	.30	.651		

The mean heart volume with ABC was 11.07 ± 4.44, which was significantly lower compared to 12.82 ± 4.68 without ABC (t = 5.944, p < 0.001). Similarly, the mean left lung volume with ABC was 22.78 ± 3.05, significantly lower than 26.81 ± 3.83 without ABC (t = 8.969, p < 0.001). For the right lung volume, the mean was 0.00 ± 0.00 with ABC and 0.30 ± 0.65 without ABC, with the difference being statistically significant (t = 2.523, p = 0.017).







Discussion

In this study, we assessed the impact of Active Breath Control (ABC) on heart and lung radiation doses during left-sided breast cancer radiotherapy. Our findings demonstrate a significant reduction in mean heart

volume and left lung volume when ABC was utilized compared to free-breathing (without ABC). These results are consistent with previous evidence emphasizing the benefits of breath-hold techniques in minimizing cardiac exposure during treatment.

A study conducted by Beena Kunheri et al, (2017) compares dosimetric parameters of the heart and left lung in left-sided breast cancer radiotherapy using active breath coordinator (ABC) moderate deep inspiratory breath hold (mDIBH) versus free breathing (FB). It found that the use of ABC mDIBH significantly reduced the cardiac dose, thereby minimizing potential cardiotoxicity. The analysis included 45 patients, documenting target coverage and dose to the heart, left anterior descending artery, and left lung, highlighting the effectiveness of ABC mDIBH for cardiac sparing[7].

The observed reduction in heart dose with ABC is clinically meaningful, considering that even low doses to the heart are associated with an increased risk of cardiac events. Earlier studies have established that the risk of major coronary events rises linearly with mean heart dose, without an apparent safe threshold. By expanding lung volume and increasing the distance between the heart and chest wall, ABC effectively decreases cardiac irradiation, aligning with the physiologic principles behind Deep Inspiration Breath Hold (DIBH) methods.

Similarly, the significant reduction in left lung dose with ABC supports the role of breath control techniques in protecting pulmonary structures. Although right lung volumes showed minor differences, these were statistically significant, highlighting the broader impact of respiratory motion management.

A study conducted by Lokesh Vishwanath et al. (2023) study compared dosimetric changes in radiation therapy for left-sided breast cancer using deep inspiratory breath hold (DIBH) versus free breathing. It found that DIBH significantly reduces radiation doses to the heart and left lung, with mean percentage volumes receiving 20 Gy (23.5% vs. 29.5%) and 25 Gy to the heart (2.9% vs. 6.7%) being notably lower. This suggests that DIBH leads to less exposure of organs at risk, potentially minimizing side effects in patients undergoing treatment[8].

Our results reinforce the growing body of evidence advocating the routine use of ABC or DIBH for left-sided breast cancer patients, especially for those requiring regional nodal irradiation, where heart proximity increases. By lowering the cardiac and pulmonary doses, these techniques potentially reduce late radiation-induced morbidity and improve long-term outcomes.

The strengths of this study include the paired comparison within the same patient cohort, minimizing inter-patient variability. However, limitations include the retrospective nature of the analysis and the relatively small sample size, which may affect the generalizability of the findings. Future larger, prospective studies could further validate these results and explore the long-term clinical benefits of incorporating ABC routinely into practice.

Conclusion

The use of Active Breath Control in left-sided breast cancer radiotherapy significantly reduces heart and lung doses. Incorporating ABC in treatment protocols may potentially lower the risk of radiation-induced cardiopulmonary toxicity, thereby improving patient outcomes.

References

1. Darby S, McGale P, Correa C, Taylor C, Arriagada R, Clarke M, et al. Effect of radiotherapy after

breast-conserving surgery on 10-year recurrence and 15-year breast cancer death: Meta-analysis of individual patient data for 10 801 women in 17 randomised trials. The Lancet [Internet]. 2011 Nov 1 [cited 2025 Apr 27];378(9804):1707–16. Available from: https://pubmed.ncbi.nlm.nih.gov/22019144/

2. McGale P, Taylor C, Correa C, Cutter D, Duane F, Ewertz M, et al. Effect of radiotherapy after mastectomy and axillary surgery on 10-year recurrence and 20-year breast cancer mortality: Meta-analysis of individual patient data for 8135 women in 22 randomised trials. The Lancet [Internet]. 2014 Jan 1 [cited 2025 Apr 27];383(9935):2127–35. Available from: https://pubmed.ncbi.nlm.nih.gov/24656685/
3. Kurtz JM. Radiotherapy for early breast cancer: Was a comprehensive overview of trials needed? Lancet. 2000 May 20;355(9217):1739–40.
4. Gyenes G, Rutqvist LE, Liedberg A, Fornander T. Long-term cardiac morbidity and mortality in a randomized trial of pre- and postoperative radiation therapy versus surgery alone in primary breast cancer. Radiotherapy and Oncology [Internet]. 1998 Aug [cited 2025 Apr 27];48(2):185–90. Available from: https://pubmed.ncbi.nlm.nih.gov/9783890/
5. Hooning MJ, Aleman BMP, Van Rosmalen AJM, Kuenen MA, Klijn JGM, Van Leeuwen FE. Cause-specific mortality in long-term survivors of breast cancer: A 25-year follow-up study. Int J Radiat Oncol Biol Phys [Internet]. 2006 Mar 15 [cited 2025 Apr 27];64(4):1081–91. Available from: https://pubmed.ncbi.nlm.nih.gov/16446057/
6. Bergom C, Currey A, Desai N, Tai A, Strauss JB. Deep Inspiration Breath Hold: Techniques and Advantages for Cardiac Sparing During Breast Cancer Irradiation. Front Oncol [Internet]. 2018 Apr 4 [cited 2025 Apr 27];8(APR):87. Available from: https://pmc.ncbi.nlm.nih.gov/articles/PMC5893752/
7. Kunheri B, Kotne S, Nair S, Makuny D. A dosimetric analysis of cardiac dose with or without active breath coordinator moderate deep inspiratory breath hold in left sided breast cancer radiotherapy. J Cancer Res Ther [Internet]. 2017 Jan 1 [cited 2025 Apr 27];13(1):56–61. Available from: https://pubmed.ncbi.nlm.nih.gov/28508834/
8. Vishwanath L, Mandal SK, Sunil RA, Latha DA, Bhaskar N, Palled SR, et al. Gated radiation therapy for patients with breast cancer to reduce the dose to the lung and heart: A comparative cross-sectional study. Cancer Research, Statistics, and Treatment [Internet]. 2023 [cited 2025 Apr 27];6(2):200–8. Available from: https:// journals. lww.com/ crst/fulltext/2023/06020/gated_radiation_therapy_for_patients_with_breast.5.aspx
9. Korreman SS, Pedersen AN, Nøttrup TJ, Specht L, Nyström H. Breathing adapted radiotherapy for breast cancer: comparison of free breathing and breath-hold techniques using a voluntary breath-hold method. Radiother Oncol. 2005;76(3):311–318.
10. Hayden AJ, Rains M, Tiver K. Deep inspiration breath hold technique reduces heart dose from radiotherapy for left-sided breast cancer. J Med Imaging Radiat Oncol. 2012;56(4):464–472.