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The Roles of Deep Inspiration Breathe Holding Using ABC-device on Lungs Doses in Left Breast Cancer Radiotherapy

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ABSTRACT

Background: Breast cancer (BC) is the most prevalent and lethal among female cancers. To reduce the risk of radiation-induced lung damage, a technique employed for left-sided breast cancer is the Deep Inspiration Breath Hold (DIBH). The study aimed to assess the impact of DIBH using the ABC device on lung dosage in left breast cancer radiotherapy.

Material and Methods: A dosimetric study was conducted involving 50 females diagnosed with left breast cancer. Treatment was conducted at Baghdad ROC using 3DCRT and at Al-Safeer Oncology Center. The research was carried out from December 2022 to May 2023, concentrating on the planning of treatment involving adjuvant radiotherapy. Demographic data of women and pathological features of breast cancer were documented. All cases received CT simulation in both phases (FB and ABC), followed by radiotherapy planning. The lung radiation doses were calculated, encompassing both average (Dmean) and maximum doses (DMax).

Results: The mean age of women in the study was 53.92 ± 10.59 years for the free breathing group (FB) (n=26) and 48.29 ± 11.82 years for the ABC group (n=24). All women received a radiotherapy dose of 40.05 G. A majority of women underwent adjuvant therapy, with 19 (38%) in the FB group and 15 (30%) in the ABC group. The majority of cases received chemotherapy. Mastectomy was conducted in 16 instances (32%) in the FB group and in 15 instances (30%) in the ABC group. The mean left lung volume of the ABC group (2028.79±265.784 cm^3) was significantly greater than that of the FB group (1070.057±232.117 cm^3), with a highly statistically significant difference ($p<0.0001$). The mean Dmax of the left lung in the ABC group (4181.887±973.139 Gy) was greater than that of the FB group (3835.2±1098.525 Gy), though the difference did not reach statistical significance.

Conclusion: The average left lung volume and average Dmax of the left lung in the ABC group are greater than those in the FB group. The use of DIBH devices is advised to reduce treatment-related morbidity and mortality, especially in relation to lung toxicity. DIBH is consistently warranted for all women receiving radiotherapy for left-sided breast cancer.

Key words: dosimetric study, Active Breathing Coordinator, free breathing, 3DCRT, deep inspiration breath holding, breast cancer

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INTRODUCTION

When it comes to cancers affecting women, breast cancer is by far the most common and second-leading killer (1,2). At 11.7% of yearly cancer diagnoses, breast cancer is by far the most common cancer among women. Its impact on mortality and morbidity rates has not diminished, even with medical breakthroughs (3). There were 6,959 female cases of breast cancer and 150 male cases recorded by the Iraqi Ministry of Health Registry in 2019 (4). With 2,088,849 new cases in 2018, breast cancer accounted for 11.6% of all cancers, and 626,679 deaths were attributed to the disease, making it 6.6% of all cancer-related deaths (5). New cases of breast cancer were 2,261,419 in 2020, accounting for 11.7% of the total. Of them, 684,996 (or 6.9% of the total) caused fatalities (3).

Deep Inspiratory Breath Hold (DIBH) is a method employed for patients with left-sided breast cancer that minimizes the likelihood of lung irradiation. The procedure entails maintaining a specific volume of air during treatment, resulting in the retraction of the lungs into the chest while the breasts receive radiation exposure. The procedure necessitates that patients with left-sided breast cancer breathe for a specified duration during treatment administration (6). Proper breathing enhances lung air volume and increases the chest surface area that absorbs medication. Extending the distance between the radiation beam and the lung diminishes the likelihood of kidney failure, which may arise three to five years post-treatment (6,7).

Varian Medical Systems' video-based real-time location (RPM) and active breathing control (ABC)-based spirometry (Stockholm, Sweden: Elekta) are the main approaches used. William Beaumont Hospital in Michigan was the site of the invention of the ABC gadget (8). With the patient's nostrils covered, the gadget acts as a mouthpiece that is linked to the spirometer, allowing for the patient to breathe exclusively through it. ABC has demonstrated the capacity to deliver up to breaths (9) and serves as an effective method for administering the DIBH technique (8,10-12). Bartlett et al (13) conducted a cross-sectional study comparing ABC DIBH and vDIBH. The VDIBH technique was initially established by regulating the transfer of the tattoo to the side with enhanced ventilation. The participant was instructed to hold his breath prior to each treatment session, with radiation administered solely when the light field and the initial field boundary were properly aligned. Set proliferation and normal cells were comparable between ABC and vDIBH. Research indicates that patients perceive the vDIBH technique as comfortable and less claustrophobic (1).

The study aimed to evaluate the impact of DIBH utilizing the ABC device on lung doses during left breast cancer radiotherapy.

MATERIAL AND METHODS

Study Design and Setting

Fifty women diagnosed with left breast cancer participated in a prospective dosimetric research. Both the Baghdad ROC and the Al-Safeer Oncology Center used 3DCRT and Active Breathing Coordinator (ABC) in combination with VMAT to provide the treatment. Treatment planning with adjuvant radiation was the primary focus of the trial, which ran from December 2022 to May 2023. Breast cancer pathological characteris-tics and women's demographic data were recorded.

Ethics

Both the Al-Safeer Oncology Hospital Ethical Committee (No. 379, 18/4/2023) and the University of Baghdad College of Medicine (No.# 1650, 30/11/2022; No.# 594, 16/4/2023) gave their approval to this study.

Inclusion Criteria

1. Women aged ≥ 18-years with BC.
2. Left BC.
3. No other primary tumors.
4. No metastatic.

Exclusion Criteria

1. Other primary tumor(s).
2. Male BC.
3. Women unable to hold their breath.
4. History of heart failure and asthma.

CT Simulation

In both the FB and ABC stages, all subjects underwent CT simulation scans before the radiation was planned. Using a Breast board (Civco, US) as a positioning device according to the case's body shape, the 132-slice CT pore scanner (Philips® 16 series, Germany) took 10-millimeter-thick CT slices. In order to facilitate treatment planning, the DICOM pictures were sent from the CT control console.

Active Breathing Coordinator (ABC, Elekta, Sweden) Device

The study's ABC device technology, developed by Elekta of Sweden, was authorized by the Al-Safeer

Oncology Center (14). The radiation dose that reached the lungs was also measured using the mean and maximum doses (Dmean and DMax, lung) and the average dose that reached the right breast (Dmean of, Lung).

Radiotherapy Doses

a) For mastectomy therapy, 40.05. Gy given in 15 portions over 3 weeks.
b) Booster radiation of 10.00 Gy administered in 5 fractions over 1 week and a total of 40.05. Gy given in 15 fractions over 3 weeks for breast-conserving surgery (2,15-18).

Statistical Analysis

We ran the analyses with SPSS 26.0, developed by SPSS Inc. and located in Chicago, Illinois, USA. Mean ± SD, frequency, and percentage are the ways in which the results are presented. Dosimetric characteristics were compared between treatment methods using paired t-tests. Statistics show that there is significance when the p-value is less than or equal to 0.05.

RESULTS

There was no significant difference (p=0.076) in the mean age of women in the free breathing group (FB) and the ABC group, with the former having an average age of 53.92±10.59 years (n=26) and the latter having an average age of 48.29±11.82 years (n=24).

There was no statistically significant difference between the two groups when it came to the most common histology, with 26 instances (52%) and 21 cases (42%), respectively, in the FB group and the ABC group indicating the presence of an IDC. There was no statistically significant difference between the groups with respect to T-stage; however, T2 was more common in the FB group (16 cases, 32%) and T1 was more common in the ABC group (9 cases, 18%). The N2 stage was seen in 12 instances (24% of the total) in the FB group, but the N1 stage was most commonly detected in the ABC group as well, with 12 cases (24% of the total). There was no discernible variation (p=0.63). Both groups had the highest frequency of tumor grade G2. With a p-value of 0.008, there was a statistically significant difference between the two groups in the LVI cohort; 14 women, or 28% of the total, in the FB group showed signs of invasive illness, whereas only four instances, or 8% of the total, in the ABC group did. Also, just 4% of women in both categories show signs of PNI.

A total of 40.05 G of radiation was given to each of the ladies. Adjuvant treatment was administered to the majority of women; 19 women (38%) in the FB group and 15 women (30%) in the ABC group got it. A large number of patients were treated with chemo-therapy. *Table 1* shows that 16 patients (32% of the total) in the FB group and 15 cases (30%) in the ABC group had mastectomy. There was no statistically significant difference (p=0.81) in the percentage of estrogen receptor positive women between the FB and ABC groups (42% vs. 40%). More specifically, 8% of the FB group and 4% of the ABC group tested positive for HER2, however there was no statistically significant difference between the two groups (p=0.443).

Lung Dosimetric

See *table 1* and *fig. 1* for the pulmonary dosimetric data comparing the ABC and FB groups. The ABC group had a considerably larger average left lung

Table 1 - Dosimetric comparison between ABC and FB among left lung

	Lt Lung vol.		Lt Lung max dose		Lt Lung mean dose	
	FB	ABC	FB	ABC	FB	ABC
Mean 1070.057	2028.79	3835.2	4181.887	1392.873	1176.956	
SE 45.522	54.253	215.438	198.64	132.226	69.455	
Median	1013.492	2014.19	4157.65	4328.7	1418.3	1261.75
SD 232.117	265.784	1098.525	973.139	674.227	340.262	
Minimum	663.933	1613.145	241.4	965.6	99	78.1
Maximum	1743.807	2847.738	4387.8	5254.2	4241.2	1515.7
Percentiles 1166.775	25	944.211	1845.234	4089.375	4245.625	1162.9
50	1013.492	2014.19	4157.65	4328.7	1418.3	1261.75
75	1160.768	2188.497	4311.55	4380.25	1455.825	1374.45
*p-value	<0.0001		0.164		0.13	

Lt: left, ABC: Active Breathing Coordinator, FB: free breathing, SD: standard deviation, vol.: volume, SE: standard error, *t-test

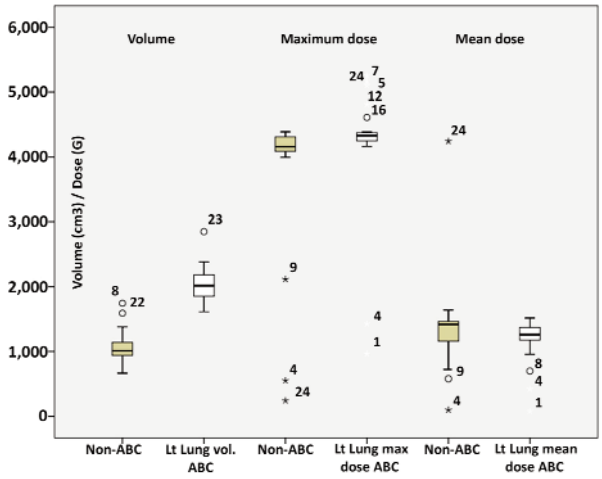

Figure 1 - Box plot of Lt lung vol., D_{max} and mean dose of ABC and FB groups

capacity (2028.79±265.784 cm^3) compared to the FB group (1070.057±232.117 cm^3), and the difference was highly statistically significant (p<0.0001). The ABC group had a higher mean Dmax of the left lung (4181.887±973.139 Gy) compared to the FB group (3835.2±1098.525 Gy), but the difference was not statistically significant. There was no significant difference (p=0.13) between the two groups, with the ABC group having a lower mean Lt lung dose (1176.956±340.262 Gy) compared to the FB group (1392.873±674.227 Gy).

DISCUSSION

Using the Elekta ABC system, 26 women who were undergoing traditional radiation (RT) with free-breathing (FB) and 24 women who were undergoing volumetric modulated arc therapy (VMAT) with deep inspiration breath-hold (DIBH) were included in this study. For women undergoing adjuvant radiation after breast-conserving surgery for left-sided breast cancer, Lee et al (2012) used the DIBH approach with Abches (Japan). A median age of 29 years (range, 23 to 76 years) and early-stage breast cancer (≤T2 and ≤N1a) were included in the case selection criteria (19).

The West Pomeranian Oncology Center's breast cancer cases from 2022 were reviewed retrospectively in 2017 by Falco et al. Out of all the patients, 99.6% were given postoperative radiation. Of those, 1049 (51.9%) were treated for left breast cancer. The majority of patients were handled utilizing 3DCRT or IMRT with FB during the research period (n=1513, 74.8%) or n=69, 3.4%). For a total of 188 patients, or 9.3%, FB-gated radiation treatment (FB-GRT) was administered. The AlignRT system, developed by Vision RT Ltd of London, UK, has been used to manage all newly diagnosed instances of left breast cancer since 2016. In 252 instances, or 12.5% of the total, the DIBH approach was used. The ladies who participated in this study were all given a total of 40.05 Gy of radiation. A large number of patients were treated with chemotherapy. Fifteen instances (30%) in the ABC group and sixteen cases (32%) in the FB group had mastectomy. The research by Falco and colleagues (2020) is in disagreement since it used a conventional dose regimen of 50 Gy (2 Gy) targeted at the chest wall in addition to node irradiation. The BCS dosage range is 10-16 Gy for each tumor bed. Depending on the patient's needs, the hypofractionated regimen might include a boost of 10 Gy or 40.05 Gy (2.67 Gy) alone (20).

With a p-value of less than 0.0001, the ABC group had a noticeably larger mean left lung capacity compared to the FB group. In comparison to the FB group, the ABC group had a higher mean left pulmonary Dmax. As a whole, the ABC group's lung dosage was less than the FB group's. There was no notable variation in the mean total dosage that the lung received in the two periods, as reported by Farzin et al. (21):(16.8±2.7) and (15.8±2.2), respectively. In FB, the average dosages administered after lumpectomy were noticeably greater (P=0.032) (21).

Wilson et al (22) and Pedersen et al (23) indicated that DIBH reduced the mean lung doses by 6.4%, a result that contrasts with our findings. Whether looking at each arm alone or all together, Yeung et al (24) could not find a statistically significant difference in left lung V20 between the two groups. The results of a randomized controlled experiment on the effects of DIBH on both sides of the lung were inconsistent. Some writers reported a considerable reduction in lung volume after administering DIBH, whereas others failed to find any such effect (23,25-28).

By inflating the lungs during DIBH, the volume of the lungs was increased, as could be seen visually. Nevertheless, when comparing the DIBH program to the FB program, there was a modest but non-significant drop in the left lung ratio (7.53 vs. 8.03 Gy, p=0.073) and lung V20 (14.63% vs. 15.72%, p=0.06) (19).

Researchers discovered that DIBH increased the capacity of the left lung. Radiation may narrow the zone of normal lung capacity, however intense

scrutiny has the ability to increase lung volume as well as decrease it (8). This suggests that radiation pneumonia is not always an increased risk associated with DIBH (19).

Lung expansion, which reduces the amount of lung tissue within the radiation field and provides a space between the lung and the target region, is one way that adaptive ventilation efficiently reduces the volume of radiation-exposed lung tissue, according to many studies. Reduced pulmonary edema was achieved by limiting lung volume to 75% of maximal inspiratory capacity using a mechanical ventilation system (29).

CONCLUSION

The current research is the first of its kind to compare FB with DIBH (an ABC device) in the adjuvant context of radiation treatment for left breast cancer in Iraq. Compared to the FB group, the ABC group had higher average left lung volumes and mean Dmaxes. It is advised that DIBH devices be used to reduce treatment-related deaths and illnesses, especially those involving lung toxicity. Every woman receiving radiation treatment for left-sided breast cancer should always wear a DIBH.

Conflict of Interest

All author declare that they have no conflict of interest.

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