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The roles of deep inspiration breathe holding (DIBH) using ABC-device on lungs doses in left breast cancer radiotherapy

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Abstract

Background: Breast cancer (BC) is the most common cancer and cause related death in women. Deep Inspiration Breath Hold (DIBH) is a technique for left-sided BC that reduces the potential impact of radiation on the lung. The study aimed to assess the roles of DIBH using ABC-device on lungs doses in left BC RT.

Methods: A prospective dosimetric study of 50 left BC females was enrolled. Which treated at Baghdad ROC (3DCRT) and at Al-Safeer Oncology Center. The study conducted in period between December 2022 and May 2023, where planning for treatment with adjuvant RT. The women's' demographic data and the pathologic features of the BC were documented. All cases underwent CT simulation in both phases (FB and ABC), then planning for radiotherapy. We calculated the radiation doses of the lung (average and maximum doses) (D_{mean} and D_{Max}, lung).

Results: The mean age of women of the study was (53.92±10.59) years for free breathing group (FB) (n=26) and (48.29±11.82) years for ABC group (n=24). All women received 40.05 G dose of radiotherapy. Most of women received adjuvant therapy in 19(38%) and 15(30%) in FB and ABC groups, respectively. Most of cases received chemotherapy. Mastectomy done in 16(32%) of cases in FB group and in 15(30%) of cases in ABC group. The mean Lt lung vol. of ABC group (2028.79±265.784 cm^3) was greater than that of FB group (1070.057±232.117 cm^3) with a highly statistical significant difference ($p<0.0001$). The mean Dmax of Lt lung in ABC group (4181.887±973.139 Gy) was greater than in FB group (3835.2±1098.525 Gy) with no significant difference.

Conclusion: The mean left lung vol. and mean Dmax of left lung in ABC group are greater than in FB group. Application of DIBH devices should be offered to reduce treatment-related morbidity and mortality especially lung toxicity. Accordingly, DIBH is justified for all women receiving RT for left-sided BC regularly.

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

INTRODUCTION

Breast cancer is the most common cancer and the second leading cause of cancer death among women [1, 2]. Although BC is the commonest cancer in women, it account for 11.7% of all cancers diagnosed each year. It is a major cause of morbidity and mortality, despite advances in medicine and treatment [3]. The Iraqi Ministry of Health Registry recorded 6,959 cases of breast cancer in women and 150 cases in men in 2019 [4]. According to GLOBCAN 2018, the number of new cases of BC was 2,088,849 (11.6%), and 626,679 (6.6%) deaths in all areas of cancer [5]. In 2020, there were 2,261,419 new cases of BC (11.7%), of which 684,996 (6. 9%) of cases died [3].

Deep Inspiratory Breath Hold (DIBH) is a technique for left-sided BC patients that reduces the risk of lung irradiation. The procedure involves retaining a certain amount of air during treatment; this causes

the lungs to move back into the chest while the breasts are exposed to radiation. The procedure requires patients with left-sided BC to breathe for a period of time while treatment is administered [6]. By breathing properly, you actually increase the volume of air in the lungs and the surface area of the chest that receives the medication. Increasing the distance between the radiation beam and the lung reduces the risk of kidney failure, which can occur three to five years after treatment [6, 7].

The two dominant methods are active breathing systems (ABC)-based spirometry (Elekta, Stockholm, Sweden) and video-based real-time location (RPM) (Varian Medical Systems, Palo Alto, CA). The ABC device was developed at William Beaumont Hospital in Michigan [8]. The device is a mouthpiece that is attached to the spirometer and the patient's nose is pinched to allow them to breathe only through the device. ABC has been shown to deliver up to breaths [9] and is an effective delivery method for the DIBH technique [8, 10–12]. Bartlett and colleagues [13] compared ABC DIBH and vDIBH in a cross-sectional study. The VDIBH technique was developed by first controlling the transfer of the tattoo to the highly ventilated side. The subject was asked to hold his breath before each treatment session, and radiation was delivered only when the light field and the first field boundary were aligned. Set proliferation and normal cells were found to be comparable between ABC and vDIBH. However, it has been shown that patients find the vDIBH technique comfortable and less claustrophobic [1].

The study aimed to assess the roles of DIBH using ABC-device on lungs doses in left BC RT.

Methods

Study Design and setting

A prospective dosimetric study of 50 left BC females were enrolled. Which treated at Baghdad ROC (3DCRT) and at Al-Safeer Oncology Center (Active Breathing Coordinator (ABC) + VMAT). The study conducted in period between December 2022 and May 2023, where planning for treatment with adjuvant RT. The womens' demographic data and the pathologic features of the BC were documented.

Ethics

This study was approved by Ethical Committee of Al-Safeer Oncology Hospital (No.3 79, 18/4/2023) and College of Medicine, University of Baghdad (No.# 1650, 30/11/2022; No.# 594, 16/4/2023).

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

All cases underwent CT simulation scans in both phases (FB and ABC), then planning for radiotherapy. CT pore scanner (132 slice, diameter 85 cm) (Philips ® 16 series, Grmany): CT slices with 10 mm thickness were acquired using Breast board (Civco, US) as a positioning device depend upon the case's body geometry. The DICOM images from the CT control console were transferred to the treatment planning system.

Active Breathing Coordinator (ABC, Elekta, Sweden) device

We used the ABC device (Elekta, Sweden) technique that found in Al-Safeer Oncology Center as we get agreement for and approval to conducted this study [14].

Also measured the radiation dose of the lung in terms of the average and maximum doses received by lung (Dmean and D_{Max}, lung) and the average dose received by the right breast (Dmean of, Lung).

Radiotherapy doses

a) 40.05 Gy/15 fractions (3 weeks) in mastectomy.

b) 40.05 Gy/15 fractions/3 weeks in BCS plus 10.00 Gy/5fractions/1week (booster) [2, 15-18].

Statistics

All analyses were conducted by using SPSS version 26.0 (SPSS Inc., Chicago, Illinois, USA). Results are presented as mean ± SD and frequency and percentage. Paired t-tests were performed to compare dosimetric parameters between treatment techniques. A p-value of ≤0.05 was statistically significant.

Results

The women mean age was (53.92±10.59) years for free breathing group (FB) (n=26) and (48.29±11.82) years for ABC group (n=24) with no significant difference (p=0.076).

The IDC was the commonest histopathology diagnosed in FB and ABC groups in (26, 52%) and (21, 42%), respectively with no significant difference (p=0.24). Regarding T-stage, the T2 was commonest in FB group (16, 32%) whereas T1 was commonest in ABC group (9, 18%), with no significant difference (p=0.124). However, N2 stage was prevalent in FB group (12, 24%) whereas N1 was commonest in ABC group (12, 24%), with no significant difference (p=0.63). In relation to tumor grades, G2 was the predominant in both arms. Among LVI, most of women in FB group (14, 28%)

showed invasive disease while only four (8%) cases in ABC group shown invasion with a high significant difference (p=0.008). In addition, only 4% of women in each groups have PNI.

All women received 40.05 G dose of radiotherapy. Most of women received adjuvant therapy in 19(38%) and 15(30%) in FB and ABC groups, respectively. Most of cases received chemotherapy. Mastectomy done in 16(32%) of cases in FB group and in 15(30%) of cases in ABC group, (Table 1). Regarding receptors, ER positive in most women 42% and 40% in FB and ABC groups, respectively, with no significant difference (p=0.81). Furthermore, HER2 was positive in 8% and 4% in FB and ABC groups, respectively, with no significant difference (p=0.443).

Lung dosimetric

The findings regarding pulmonary dosimetric comparison between ABC and FB groups were figured in Table 1 and Figure 1. The mean Lt lung vol. of ABC group (2028.79±265.784 cm^3) was greater than that of FB group (1070.057±232.117 cm^3) with a highly statistical significant difference (p<0.0001). The mean Dmax of Lt lung in ABC group (4181.887±973.139 Gy) was greater than in FB group (3835.2±1098.525 Gy) with no significant difference. The mean of Lt lung mean dose of ABC group (1176.956±340.262 Gy) was lower than that of FB group (1392.873±674.227 Gy) with no significant difference (p=0.13).

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	25	944.211	1845.234	4089.375	4245.625	1162.9	1166.775
	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

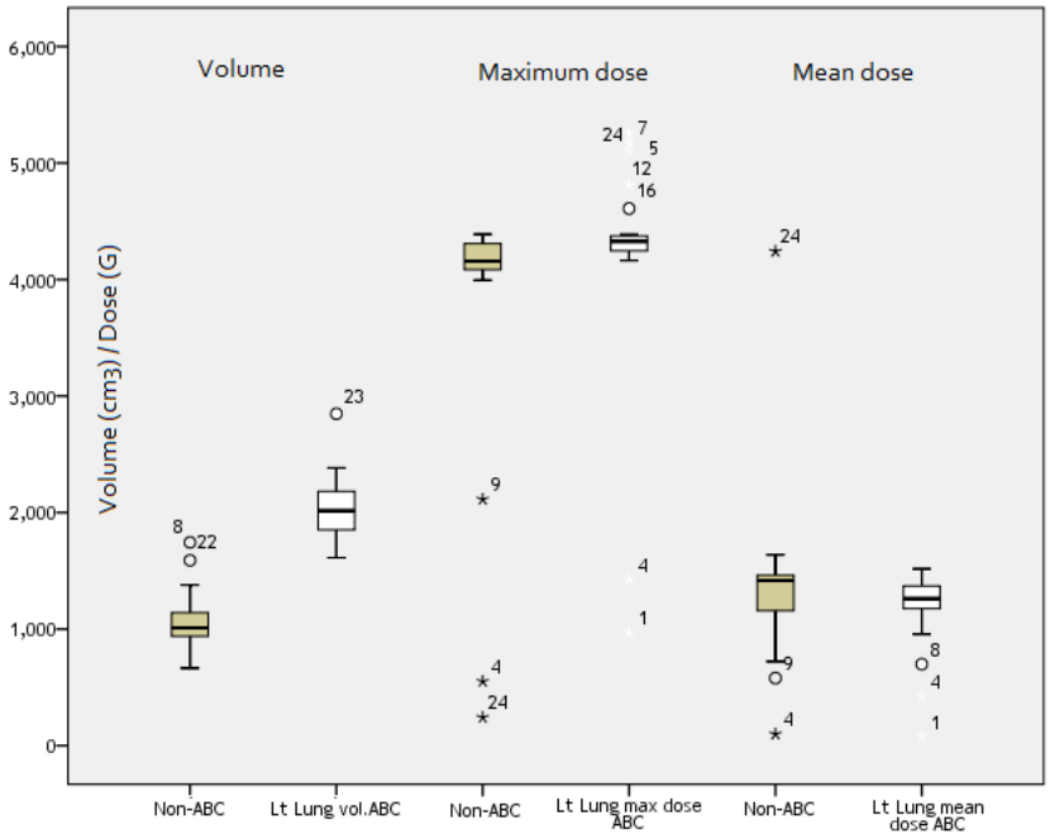

Figure 1. Box plot of Lt lung vol. , D_{max} and mean dose of ABC and FB groups.

Discussion

In this study, 26 women underwent conventional RT using FB and 24 women underwent VMAT by DIBH using ABC from Elekta. In 2012, Lee et al., implemented the DIBH technique using Abches (Japan) for women undergoing adjuvant RT after BCS for left-sided breast carcinoma. Case selection criteria were early stage (≤T2 and ≤N1a stage) BC with median age of these cases was 29 years (range, 23 to 76 years) [19].

Falco et al., [20] retrospectively analyzed 2022 cases of BC at West Pomeranian Oncology Center in 2017. All cases (99.6%) received postoperative RT and 1049(51.9%) were treated for left BC. During the study period, most cases were treated with 3DCRT (n=1513, 74.8%) or IMRT (n = 69, 3.4%) with FB. A total of 188 cases (9.3%) underwent FB-gated (FB-GRT). Starting in 2016, all new left BC cases were treated with DIBH (AlignRT system Vision RT Ltd, London, UK). The DIBH technique was applied in 252(12.5%) cases.

In present study, all women received 40.05 Gy of RT. Most of cases received chemotherapy. Mastectomy done in 16(32%) of cases in FB group and in 15(30%) of cases in ABC group. Dislike with study of Falco and colleagues (2020), that used standard dosing schedule of 50 Gy (2 Gy) to the chest wall with irradiation of the nodes. In cases of BCS, a dose of 10-16 Gy / tumor bed is recommended. The hypofractionated regimen was 42.5-45 Gy (2.25-2.5)+ 10 Gy boost or 40.05 Gy (2.67 Gy) without boost [20].

In this study, the mean Lt lung vol. of ABC group was greater than that of FB group with a highly statistical difference ($p<0.0001$). The mean D_{mean} of Lt lung in ABC group was greater than in FB group. The mean of Lt lung mean dose of ABC group was lower than that of FB group. Disagrees with Farzin et al, [21] reported insignificant difference in the mean overall dose received by the lung in both phases were (16.8±2.7) and (15.8±2.2), respectively. In addition, the average doses received was significantly more in FB in lumpectomy ($P=0.032$) [21].

Wilson et al, [22] and Pedersen et al, [23] reported that DIBH dropped the mean doses of the lung by 6.4%, which is not similar to our findings.

There was no significant difference between both arms in left lung V20 for either cohort alone or for all cases combined in the study of Yeung et al, [24]. A randomized controlled trial showed variable results regarding the effects of DIBH on both sides of the lung. Some authors reported that DIBH significantly reduced lung volume, while others showed no difference [23, 25-28].

Although lung inflation during DIBH increased the lung volume in the field by eye examination, the ratio of the left lung (7.53 vs. 8.03 Gy, $p= 0.073$) and lung V20 (14.63% vs. 15.72%, $p=0.06$) declined with DIBH compared to the FB program, but the difference was not significant [19].

It was observed that left lung volume increased with DIBH. Although lung volume can be increased by intensive examination, lung volume can be reduced, which can cause radiation that narrows the area of normal lung volume [8]. Therefore, the risk of developing radiation pneumonia may not increase when the DIBH technique is used [19].

Many studies have shown that adaptive ventilation can be used to reduce the size of the radiation-free lung, particularly by using lung inflation, which reduces the amount of lung tissue in the radiation field and separates the lung from the target. A mechanical ventilation device was used to limit lung volume to 75% of maximum inspiratory capacity and thus reduce pulmonary edema [29].

Conclusion

To our knowledge, this is the first time study conducted in Iraq compare between DIBH (ABC devise) and FB in adjuvant setting of left BC RT. The mean left lung vol. and mean Dmax of left lung in ABC group are greater than in FB group. Application of DIBH devices should be offered to reduce treatment-related morbidity and mortality especially lung toxicity. Accordingly, DIBH is justified for all women receiving RT for left-sided BC regularly.

Disclosure

None

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