



## Case Report

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# Dosimetric Evaluation of Breathing-Adapted Radiotherapy for Right-Sided Breast Cancer



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## Abstract

In the context of breast cancer radiotherapy, there is scant data regarding the use of Active Breathing Control (ABC) system for breathing-adapted right-sided breast cancer radiotherapy. Herein, we report a case of right-sided breast cancer treated using breathing-adapted radiotherapy with the ABC system. We report a 45-year-old woman suffering from right-sided breast cancer who received precision radiotherapy with moderate deep inspiration breath holding (mDIBH) by use of the ABC system. Two different radiation treatment plans (with and without breath holding) were generated, and dose-volume histograms were used for dosimetric comparison of dose-volume parameters in both free breathing (FB) and mDIBH plans. In our case, dosimetric comparison of free breathing and mDIBH plans revealed clearly improved critical organ sparing through incorporation of mDIBH with the ABC system, which may have potential implications for routine adoption of breathing maneuvers for radiation treatment of both left and right sided breast cancer patients.

**Keywords:** Breast Cancer; Radiotherapy; Active Breathing Control; Breath holding

**Abbreviations:** ABC: Active Breathing Control; mDIBH: Moderate Deep Inspiration Breath Holding; FB: Free Breathing; DVH: Dose-Volume Histograms; CT: Computed Tomography

## Introduction

Breast cancer is the most common cancer in females worldwide as a major health concern [1-3]. Radiation therapy plays a central role in the management of breast cancer with its benefit in terms of local control and survival [4-8]. Radiation therapy for breast cancer typically targets the breast or the chestwall and lymph nodes when indicated. Since these targets are located in vicinity of critical structures such as the lungs, heart and vessels, radiation-induced toxicity and morbidity may be considered as important concerns for long-term survivors of breast cancer.

Minimizing radiation-induced adverse effects has become a more important focus given that more patients are diagnosed with early stage breast cancer due to improved screening and life expectancy is longer in the era of more effective management alternatives. Thus, incorporation of recent technology into clinical practice is gaining utmost priority for contemporary breast cancer radiotherapy. Primary goal of radiation therapy is to achieve effective doses in the target volumes with thorough

sparing of normal tissues for an optimal therapeutic ratio. A variety of adaptive radiotherapy techniques and breathing maneuvers such as active breathing control may be utilized to improve treatment precision and outcomes of radiotherapy [9-12].

In the context of breast cancer radiotherapy, several studies have reported improved critical organ sparing and dosimetric results with adoption of breathing maneuvers particularly for left-sided breast cancer patients [11-14]. Herein, we report a case of right-sided breast cancer treated using breathing-adapted radiotherapy with Active Breathing Control (ABC) system.

## Case Report

A 45-year old female patient with right-sided invasive ductal breast cancer was referred for adjuvant radiotherapy after subcutaneous mastectomy. Two radiotherapy treatment plans were generated for the patient with and without incorporation of moderate deep inspiration breathe holding

(mDIBH) using the Active Breathing Control (ABC) system. Before computed tomography (CT)-simulation for radiation treatment planning, the patient received a brief training session to improve compliance with the ABC system (ABC, Elekta, UK) and to detect customized mDIBH level which was set at 75% of maximum inspiratory capacity. The patient was informed about the breath holding procedure and expected benefits. The patient received verbal instructions and practiced mDIBH since a steady breathing pattern was assured. Her mDIBH threshold and tolerated mDIBH duration was noted to be used throughout the radiation treatment course. ABC system was used to monitor breathing trace by use of the patient mouthpiece connected to the system. For CT simulation, two sets of CT images were acquired both at free breathing (FB) and mDIBH to be able to assess dosimetric impact of the ABC process.

Patient immobilization was performed by use of an angled breast-board in supine position with both arms above the head. After patient training, immobilization and positioning procedures; radiation treatment simulation was performed at the CT-simulator (GE Light speed RT, GE Healthcare, Chalfont St. Giles, UK). First CT scan was acquired at mDIBH using the ABC system which was followed by a second CT scan at free breathing (FB) to use for comparative dosimetric assessment. Slice thickness was set at 3.75 mm for both FB and mDIBH scans. Images acquired at CT simulation with both FB and mDIBH

conditions were then sent to the delineation workstation by use of the network. Delineation procedures including target and critical organ contouring were performed by using the Advantage Sim MD simulation and localization software (Advantage SimMD, GE, UK). The same window level was used for contouring and same physician and physicist conducted treatment planning processes with and without mDIBH to improve consistency and concordance.

Two different radiation treatment plans (with and without mDIBH) were generated using the Precise PLAN (Elekta, UK) Treatment Planning System by use of identical beam organizations, wedges, and beam angles. Comparison of the 2 different radiation treatment plans was achieved by use of dose-volume histograms (DVH). The patient was treated using a dose of 50 Gy in 25 fractions by use of a linear accelerator (Synergy, Elekta, UK). Dose-volume parameters including mean heart doses, mean liver doses, liver V30, mean lung dose (MLD) and lung V20 parameters were extracted from the two different DVH for dosimetric comparison of FB and mDIBH radiation treatment plans. Figure 1 shows DVHs acquired from mDIBH (on the left) and FB (on the right) radiation treatment plans and Table 1 shows the dose-volume parameters acquired from FB and mDIBH radiation treatment plans and % decrease with mDIBH (Figure 1).

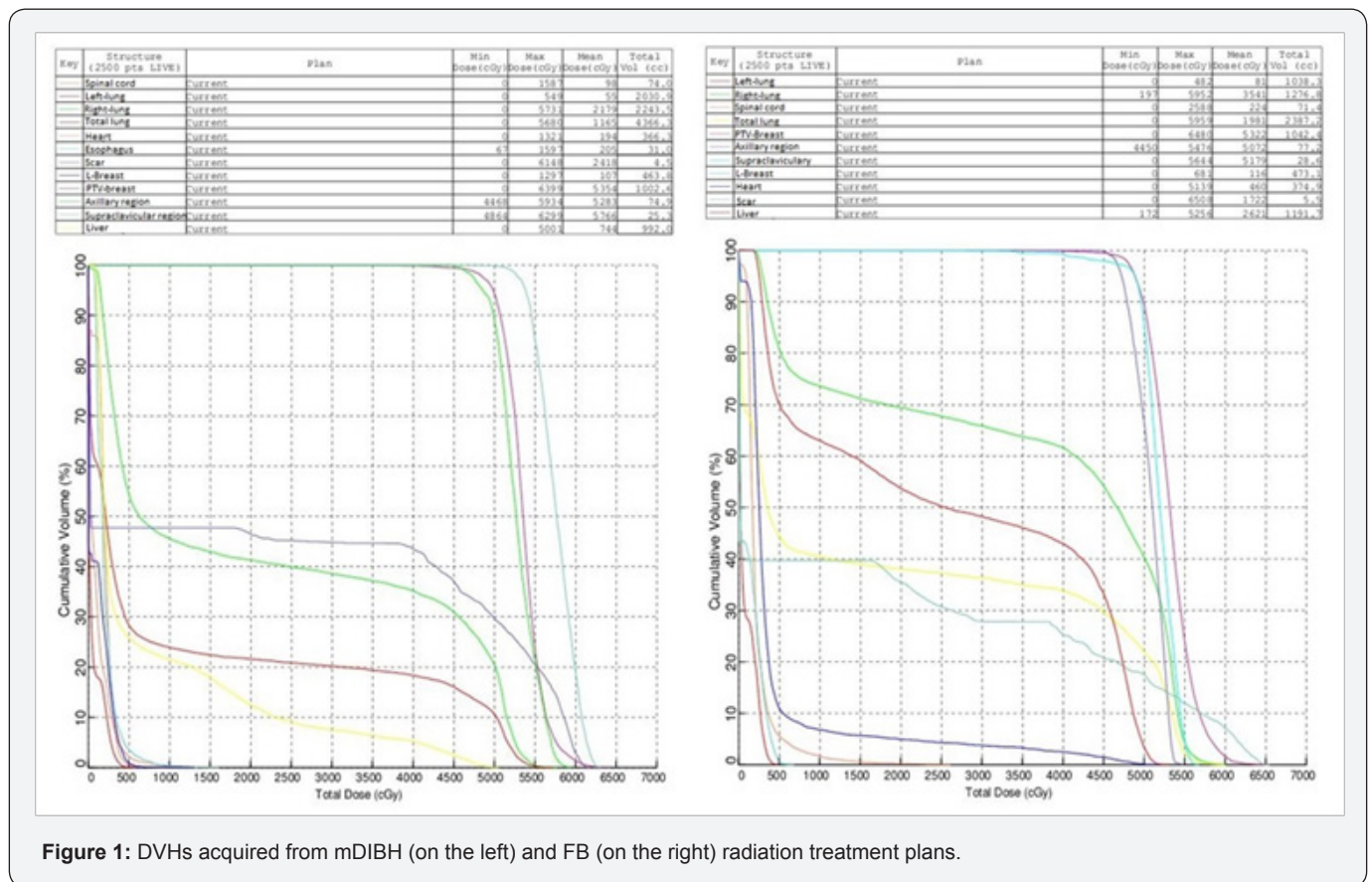
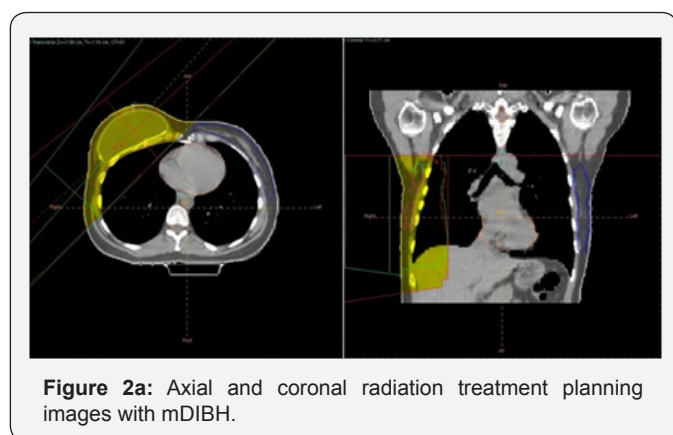


Figure 1: DVHs acquired from mDIBH (on the left) and FB (on the right) radiation treatment plans.

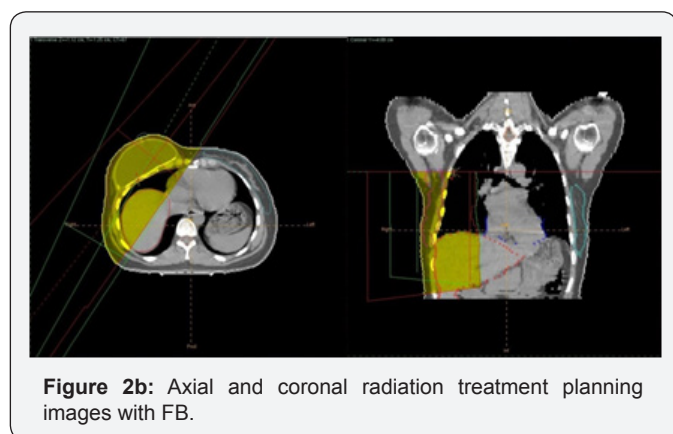
**Table 1:** Dose-volume parameters acquired from FB and mDIBH radiation treatment plans and % decrease with mDIBH.

Technique	DIBH			Free Breathing			% Decrease with mDIBH
	Mean (cGy)	Min (cGy)	Max (cGy)	Mean (cGy)	Min (cGy)	Max (cGy)	
Liver	744	0	5001	2621	172	5256	72
Liver V30	8 %	48 %	83.4				
Total lung	1165	0	5680	1981	0	5959	41.2
Heart	194	0	1321	460	0	5139	57.9
Right lung	2179	0	5731	3541	197	5952	38.5
Right lung V20	42 %			70 %			40
Left lung	55	0	549	81	0	482	32.1
Left breast	107	0	1297	116	0	681	7.8
PTV	5354	0	6399	5322	0	6480	-

Axial and coronal radiation treatment planning images with mDIBH and with FB are shown in Figures 2a & Figure 2b, respectively.



**Figure 2a:** Axial and coronal radiation treatment planning images with mDIBH.



**Figure 2b:** Axial and coronal radiation treatment planning images with FB.

**Discussion**

Dosimetric comparison of FB and mDIBH radiation treatment plans revealed improved critical organ sparing with incorporation of breath holding using the ABC system (Table 1 and Figure 1). Several studies have typically focused on left-sided breast cancer patients and reported improved critical organ sparing and dosimetric results with adoption of

breathing maneuvers [11-14]. In this context, our encouraging results may have implications for adoption of breathing-adapted radiotherapy with Active Breathing Control for right-sided breast cancer patients given the scant data in the literature. Breast cancer is common among female patients and radiation-induced toxicity and morbidity is gaining more importance with improved survival of patients due to increased public awareness and more effective therapies. In this regard, methods to improve critical organ sparing are widely accepted in the discipline of radiation oncology in the modern treatment era.

ABC system has been shown to be a viable method for management of respiratory motion for precision radiotherapy and several studies have reported improved critical organ sparing by use of ABC, we have rapidly adopted this system in our clinic for both conventionally fractionated treatments and stereotactic irradiation in an effort to improve radio therapeutic outcomes [10-16]. In our case, dosimetric comparison of FB and mDIBH plans revealed clearly improved critical organ sparing through incorporation of breath holding at moderate deep inspiration with the ABC system, which may have potential implications for routine adoption of breathing maneuvers for radiation treatment of both left and right-sided breast cancer patients.

**Conclusion**

In conclusion, breath holding at mDIBH with the ABC system has proved to yield a favorable dosimetric advantage in our patient with right-sided breast cancer and our encouraging results may have potential implications for routine adoption of breathing maneuvers for radiation treatment of right-sided breast cancer patients in addition to left sided breast cancer patients. Further supporting evidence is clearly warranted before widespread clinical adoption of this technique.

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