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ORIGINAL ARTICLE

Arms Positioning Effect on Dose Distribution in Target and Organs at Risk in Breast Radiotherapy after Breast-Conserving Surgery

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Abstract

Purpose: Breast cancer is the second most common cancer in women. This study aims to evaluate the effect of the patient's arm positioning on dose distribution in Planning Target Volume (PTV) and Organs At Risk (OARs) in radiotherapy after Breast-Conserving Surgery (BCS).

Materials and Methods: Thirty patients were divided into two groups; each group included 15 patients, including those in the left arm-up position (group 1) and both arms-up positions (group 2). The patients were selected randomly, and both groups were planned based on 16-slice Computed Tomography (CT) with a 5 mm slice thickness. The patients had been treated with 6 MV photon beam energy at the prescribed dose of 50 Gy in 25 fractions, and planning was performed using the Monaco Treatment Planning System (TPS). The results of dose parameters for the PTV, such as minimum dose (D_{min}), mean dose (D_{mean}), maximum dose (D_{max}), Heterogeneity Index (HI), and Conformity Index (CI), were obtained. For OARs, dose parameters such as Dmin, Dmean, and D_{max} were calculated. TCP for tumors and NTCP for OARs were also evaluated as radiobiological parameters.

Results: There was no statistically significant difference between the two groups in terms of dose parameters in PTV, but there was a difference for the OARs, such as thyroid.

Conclusion: The patient's arm position significantly affects the dose distribution for OARs such as the thyroid ($p<0.05$), and the position of both arms up (group 2) is relatively better than the left arm up (group 1) due to some clinical reasons.

Keywords: Breast Cancer; Radiotherapy; Arms Positioning; Dose Distribution; Treatment Planning.

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1. Introduction

Breast cancer is the second most common cancer in women worldwide. Breast-conserving surgery is performed on patients in the early stages [1]. The choice of optimal patient positioning in radiotherapy is essential for reducing radiation exposure to healthy organs. Patient positioning in radiotherapy is essential for reducing radiation exposure to healthy organs [2].

For the supine position, though the treatment position allows for the use of the arms-up position, the dosimetric effect of this position on PTV and OARs has not yet been determined. The repeatability of holding one's arms up throughout daily therapies has also not been established [3]. Therefore, assessing the differences in treatment planning and evaluating the effect of the position of the arms of patients during radiotherapy can be useful in determining the dosimetric effect of this position on dose in PTV and minimizing the dose to OARs [4–13]. TCP for tumors and NTCP for OARs are two quantities that are normally applied as radiobiological parameters for the evaluation of radiotherapy plans.

In some recent studies, the differences in organ at risk (OAR) sparing in various positions (supine position, prone position, and crawl position) were evaluated for breast cancer patients undergoing radiotherapy after surgery. However, to the best of our knowledge, data regarding the reproducibility of arm positions and the dosimetric impact of arm positioning on PTV, as well as the reduction in dose to the OARs during breast cancer radiotherapy, are currently lacking [14–17].

This study aims to evaluate the effect of patient arm positioning on the breast board on dose distribution in PTV and OARs in radiotherapy after Breast-Conserving Surgery (BCS). Additionally, the effect of patient arm positioning on TCP for tumors and NTCP for OARs (as radiobiological parameters) is also evaluated.

2. Materials and Methods

2.1. Characteristics of Patients

Thirty patients who underwent radiotherapy after BCS and were planned to undergo 3-dimensional conventional radiotherapy (3DCRT) were evaluated. These patients have been randomly selected from various age groups and have been diagnosed with left breast cancer. Based on the position of their arms, the patients were divided into two different groups; each group included 15 patients. The first group had the left arm up and the right arm alongside the body, with the head rotated 10–20 degrees to the right side. The second group had both arms up, and the head position was straight.

Patients were randomly selected, not based on tumor size or breast size. The characteristics of the patients that were adopted in the first group are the same as those in the second group. Which includes that the ages are close between the two groups, the choice of the stage of the disease, the location of the left breast, and the prescribed dose 50 (Gy), in addition to some of the characteristics that were mentioned in Table 1. Table 1 lists patients' characteristics, including the number of patients, age of patients, prescribed dose (Gy), PTV volume (cc), and volumes of OARs (cc).

Table 1. Characteristics of the patients who underwent radiotherapy after BCS in the present study

Characteristics	Number
Number of female patients	30
Age, range in years	34-50 (average 33)
Prescribed dose (Gy)	50 Gy
PTV (cc)	1283.85±65.00
Heart volume (cc)	592.80±35.00
Spinal cord volume (cc)	35.36±3.70
Left lung volume (cc)	1013.35±52.00
Thyroid volume (cc)	22.79±5.58

2.2. Treatment Planning

As it is clear from Figure 1, the first group was in the one-arm-up position (group 1), while the second group assumed the both-arms-up position (group 2). In the first group, the left arm-up positioning was employed to facilitate tangential fields across the chest without irradiating the arm. The patients were positioned supine, with the arm on the affected side (ipsilateral) lifted during breast irradiation. The left arm grasped the breast board handle in the case of left-side breast tumors, while the other arm was positioned along the right lateral line of the body. To increase the distance between the face and the radiation beam, the head was extended, and the face was turned to the opposite side.

The left arm up (group 1) and the two arms up (group 2) positioning are illustrated in Figure 1 (parts (a) and (b), respectively). The radiopaque markers were also indicated in this figure by red dots. As it is evident from this figure for group 1 (Figure 1, part (a)), six radiopaque markers (three in the midline and one in the left axilla) were used. For group 2, nine radiopaque markers (three in the midline, three in the left axilla, and one in the right axilla) were used. For the three midline markers, the superior one is located on the suprasternal notch, the middle one is located at a stable place between breasts, and the inferior one is located 2 cm below the breast. We use these markers for the purpose of setting up the patients by aligning the sagittal laser and for referencing and addressing. There were also three other markers on the mid-axilla aligned with midline markers. All of the mid-axilla markers were used to control the rotation of the patients. Herein, rotation means the distance (in cm) of the marker from the couch top. Any rotation of the patient in different sessions could be prevented by measuring this distance. For group 2 (Figure 1, part (b)), three additional markers were used on the right mid-axilla, aligned with other markers. These are used to have better fixation, setup accuracy, and precision. After the CT simulation, the positions of the six or nine markers were tattooed on the patient's body with a pen. In both groups, for positioning the head, another marker was placed on the patient's mandible and aligned with the sagittal laser and the midline markers.

CT images of the patients were utilized. This CT examination was part of the routine patient radiation therapy schedule, so no additional radiation exposure was incurred by the patients. For both groups, a Neusoft CT scan machine (NeuViz 16, Neusoft Medical System Co., China) located in the Radiation Oncology Center at Vali Asr Hospital (Qom, Iran) was employed for imaging. Since the CT imaging of the patients was performed in two different centers, to overcome the uncertainty related to this difference in dose calculations, the CT number curves for both groups were calibrated at the Radiation Oncology Center of Shahid Beheshti Hospital (Qom, Iran). In the next step, a contouring atlas with two arms was established, and to ensure consistency in the planning of treatments for the two groups, treatment planning was performed with the same treatment planning system (TPS) for both groups.

After importing CT image files to TPS, the treatment plans were designed to perform dose calculations. An authorized radiation oncologist determined that the gross target volume (GTV) and PTV were taken into account with a 10 mm margin to the clinical target volume (CTV) to allow for patient movement and positioning uncertainties. The oncologist then identified the OARs and some other sensitive organs, including the heart, lung, spinal cord, and thyroid. In the instance of breast reconstruction, the PTV covered the ipsilateral chest wall, including the breast prosthesis, as well as all local lymph nodes, such as the supraclavicular lymph nodes. Patients with

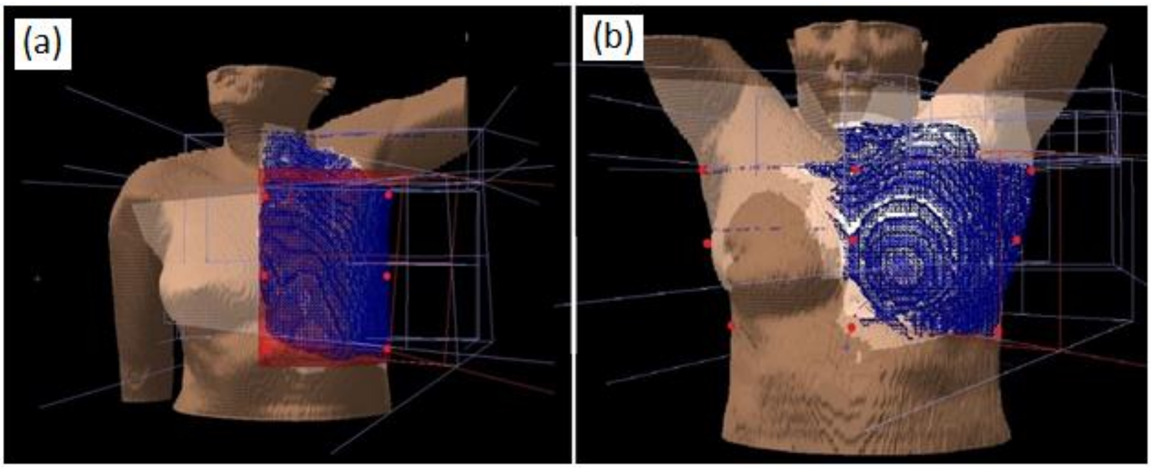

Figure 1. Illustration of (a): position of left arm up (group 1) and (b): position of two arms up (group 2) in a patient who underwent radiotherapy after BCS. The radiopaque markers were also indicated in this figure by red dots

supraclavicular lymph node tumor involvement were also selected. For both groups, the radiation fields included tangential and supraclavicular fields. Since the patients had left breast cancer, the supraclavicular fields were located on the left part of their bodies. The heart, lungs, thyroid gland, and spinal cord were delineated as OARs. The lung's contours were delineated using anatomic segmentation.

A medical physicist created the treatment plan. A physicist's perspective can differ when evaluating a plan to achieve the optimum plan. The radiotherapy beam introduced in the TPS was the 6 MV energy photon beam of an Elekta Synergy Platform linear accelerator (Elekta, Sweden). The Monaco treatment planning system (TPS) (version 5.11.03, Elekta, Sweden) with the Monte Carlo dose calculation algorithm was utilized for the treatment planning of the patients. A 3 mm dose calculation matrix was used in the treatment planning calculations. Treatment planning was performed with the aim of delivering the prescribed dose of 50 Gy to PTV over the course of 25 fractions.

In Figures 2 and 3, samples of treatment plan images for the left arm-up position (group 1) and the right arm-up position (group 2) are presented, respectively.

Based on the treatment planning, the following dosimetric parameters were used to compare the two groups with each set of plans: doses received by PTV, including D_{min}, D_{mean}, D_{max}, HI, and CI. For the lung, V20 Gy (%) (percentage of lung volume that receives a 20 Gy dose), and for the other OARs, D_{min}, D_{mean}, and D_{max} were evaluated.

Dose Volume Histograms (DVHs) were created, and the necessary parameters were used. Dose distribution, including D_{min}, D_{mean}, D_{max}, and heterogeneity index (HI), comes from the calculations of the pre-calibrated treatment planning system. The Conformity Index (CI) was calculated according to the following formula [18] (Equation 1):

$$\text{Conformity index } = \frac{TV_{RI}}{TV} \tag{1}$$

The parameter TV_{RI} is the reference isodose coverage of the target volume, and TV is the target volume.

In addition to the dosimetric parameters, TCP for tumors and NTCP for OARs were also evaluated as the radiobiological parameters of the two groups. For the calculation of TCP and NTCP, the Niemierko model was used [19], and cumulative DVHs of the plans for two groups were extracted from the TPS. Sample DVHs are presented in Figure 4 for a patient with the left arm position (group 1, part (a)) and for a patient with both arms up (group 2, part (b)).

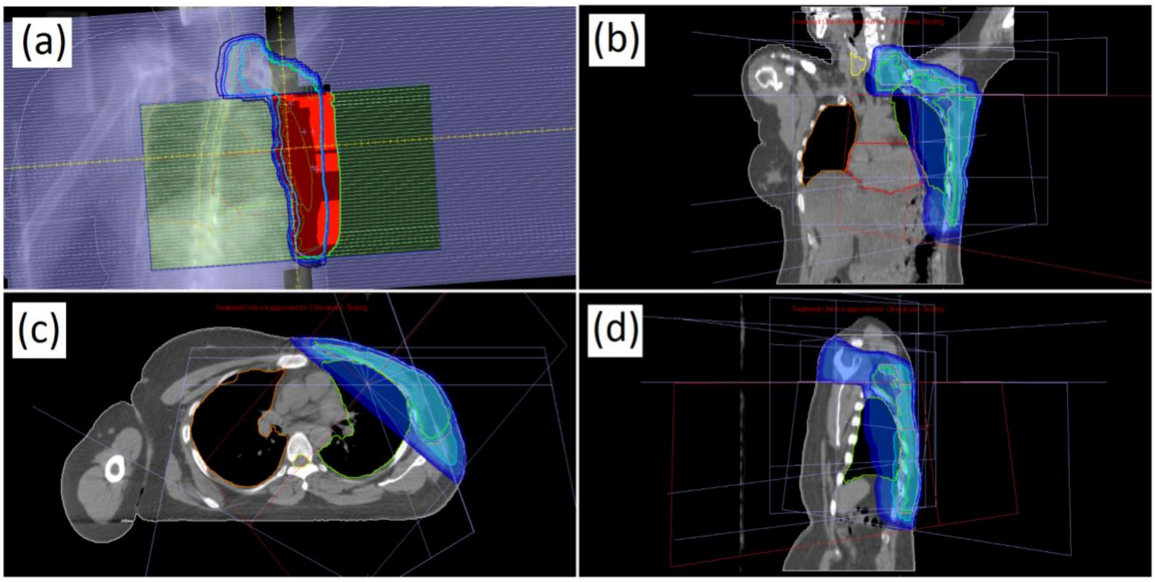

Figure 2. Treatment plans for a sample patient with left arm up position (group 1) underwent radiotherapy after BCS; (a): multileaf collimator (MLC) view on the TPS; (b): coronal view; (c): axial view, and (d): sagittal view

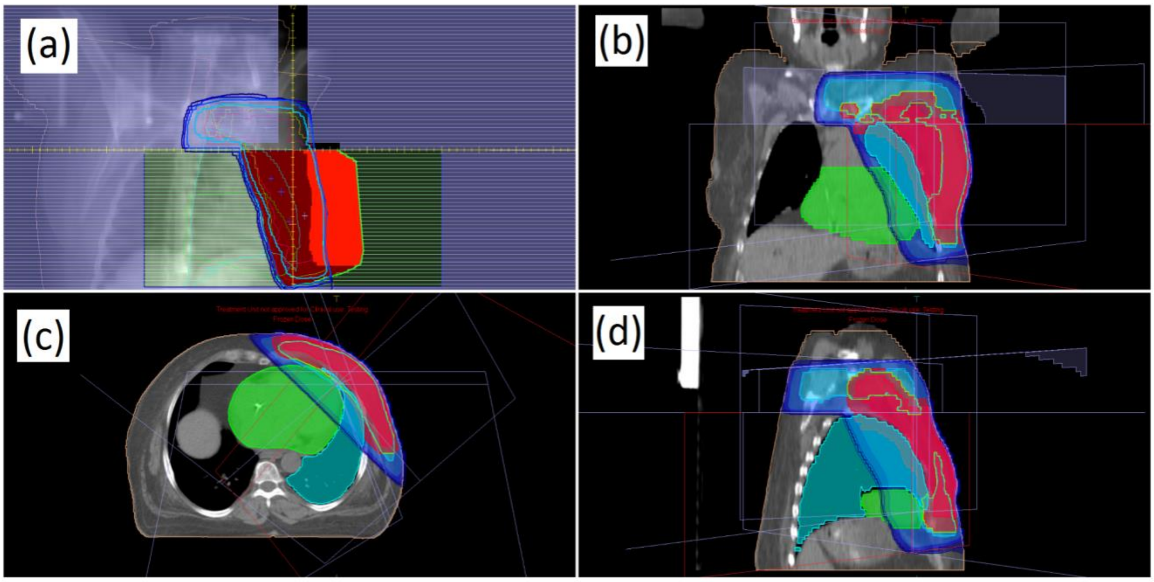

Figure 3. Treatment plans for a sample patient with both arms up position (group 2) underwent radiotherapy after BCS; (a): multileaf collimator (MLC) view on the TPS; (b): coronal view; (c): axial view, and (d): sagittal view

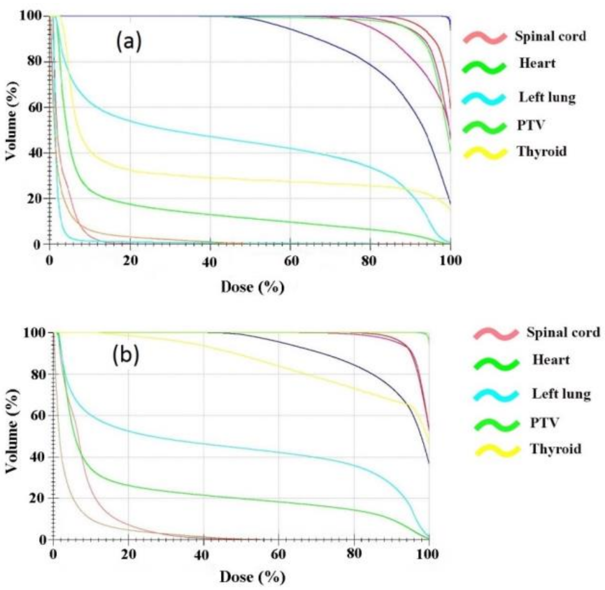

Figure 4. Sample DVHs for a patient with left arm up position (group 1, part (a)) and a patient with both arms up position (group 2, part (b)) underwent radiotherapy after BCS

The equivalent uniform dose (EUD) was calculated according to the following Equation 2:

$$\mathrm{EUD} = \left(\Sigma_{\mathrm{i}=1}(V_{\mathrm{i}}\mathrm{D}_{\mathrm{i}}^{\mathrm{a}})\right)^{\frac{1}{\mathrm{a}}} \quad (2)$$

Where V_i is a value with no dimensions that represents the partial volume, and "a" is a model parameter with no units for the tumor or the normal structure of interest, D_i is the received dose in Gy.

TCP and NTCP were calculated according to the Equations 3 and 4, respectively:

$$\mathrm{TCP} = \frac{1}{1 + \left(\frac{\mathrm{TCD}_{50}}{\mathrm{EUD}}\right)^{4\gamma 50}} \quad (3)$$

$$\mathrm{NTCP} = \frac{1}{1 + \left(\frac{\mathrm{TD}_{50}}{\mathrm{EUD}}\right)^{4\gamma 50}} \quad (4)$$

Where TCD_{50} is the tumor dose to control 50 percent of the tumors when the tumor is uniformly irradiated. TD_{50} is the tolerance dose for a 50 percent complication rate at a specific time interval when the entire organ of interest is uniformly irradiated. And γ_{50} is a unit-less model parameter that is specific to the tumor of interest and describes the slope of the dose-response curve.

Different parameters (γ_{50}, TCD_{50}, and TD_{50}) that are required for the calculation of TCP and NTCP based on the Niemierko model can be found in the literature [20-21].

Statistical Analysis to Compare two Groups

Statistical package for the social sciences (SPSS) software (version 26, SPSS Inc., Chicago, USA) was used for statistical analysis. The Schapiro walk test was applied to the findings to ascertain if the data had a normal or non-normal distribution. For each group, one sample test was used to compare D_{mean} for PTV with the prescribed dose and the organ dose with the tolerance dose for each OAR. To compare the two arms positioning groups with each other to know which group is better in terms of dose distribution in PTV and OARs, the independent *t*-test was used to analyze the data, having a normal distribution. A significant difference between the two groups that were compared was defined as $p > 0.05$. The Mann-Whitney test was utilized for comparison of the data with a non-normal distribution.

D_{min}, D_{mean}, D_{max}, HI, CI, and TCP for PTV and D_{min}, D_{mean}, D_{max}, $V_{20\ Gy}$ (%) (for lung), and NTCP for the OARs (heart, lung, spinal cord, and thyroid) were evaluated for each group separately, and the two groups were compared with each other in terms of these quantities.

3. Results

Dosimetric results for Dmin, Dmean, D_{max}, HI, CI, and TCP for PTV for patients with the left arm up position (group 1) and patients with both arms up positions (group 2) are presented in Table 2. Additionally, results for comparison of Dmin, Dmean, D_{max}, and NTCP for OARs between these two groups are listed in this table. All data were evaluated at a significant level of $p < 0.05$. The data are related to the patients receiving radiotherapy after BCS.

4. Discussion

In order to specify the better group in terms of dose distribution in PTV and OARs, the two groups are compared. For statistical normality, the results have an

Table 2. Dose distribution quantities, TCP and NTCP for PTV and OARs for the left arm up position (group 1) and both arm up positions (group 2) for patients who underwent radiotherapy after BCS. *the p-value is less than 0.05

	Organ	Quantity	Left arm up	Both arms up	*p*-value
			Mean ±SD	Mean ±SD	
Target	PTV	D_{min} (Gy)	27.88±8.14	27.87±6.85	1.00
		D_{mean} (Gy)	49.87±1.17	50.69±0.4	0.12
		D_{max} (Gy)	54.92±0.49	55.10±0.86	0.87
		HI	1.13±0.04	1.14±0.02	0.71
		CI	0.67±0.09	0.74±0.07	0.08
		TCP (%)	91.95±3.69	91.63±3.66	0.96
OARs	Heart	D_{mean} (Gy)	9.26±3.39	12.27±4.32	0.55
		NTCP (%)	0.00±0.00	0.00±0.00	0.80
	Left lung	$V_{20\ Gy}$ (%)	34.92±5.56	38.00±5.21	0.14
		NTCP (%)	0.02±0.01	0.02±0.02	0.71
	Spinal cord	D_{max} (Gy)	29.30±9.70	29.62±6.39	0.93
		NTCP (%)	0.26±0.09	0.29±0.15	0.62
	Thyroid	D_{min} (Gy)	1.85±0.62	2.81±1.13	<0.01*
		D_{mean} (Gy)	26.10±4.12	30.96±7.53	0.04*
		D_{max} (Gy)	50.70±1.60	52.30±2.86	0.04*
	Thyroid				

abnormal distribution for D_{min}, D_{mean}, D_{max}, CI, HI, and TCP ($p< 0.05$) for the left arm up position (group 1) and both arms up positions (group 2) for PTV, Dmin, Dmean, D_{max}, and NTCP for the left arm up position (group 1) and both arms up positions (group 2) for OARs. Therefore, the Mann-Whitney U-test was used for comparison between the two groups in terms of PTV and OARs.

Comparison of two groups in terms of dose distribution in PTV

For both groups, the prescribed dose was 50 Gy, and in some cases in group 1 and some cases in group 2, D_{mean} in the PTV was higher than 50 Gy due to the dose coverage of 95% volume of the PTV to 107% dose, as a criterion. The average D_{mean} and prescribed dose are 49.87 Gy and 50.00 Gy, respectively, for left arm up position patients (group 1), and there is no statistically significant difference between the D_{mean} and the prescribed dose for the left arm up position (group 1) ($p > 0.05$). The average for D_{mean} and the prescribed dose are 50.69 Gy and 50.00 Gy, respectively, for both arms-up position patients (group 2), and there is no statistically significant difference between D_{mean} versus the prescribed dose for group 2 ($p > 0.05$). Therefore, the D_{mean} is very close to the prescribed dose for both groups, and this is the goal of having adequate dose distribution in PTV to destroy the target cancer cells. On the other hand, the D_{mean} for left arm up position (group 1) is close to the prescribed dose (99.74% relative to the prescribed dose) compared to the D_{mean} for the both arms up position (group 2) (101.38% relative to the prescribed dose). However, there is no statistically significant difference between the D_{mean} for the left arm up position (group 1) and the both arms up position (group 2) ($p > 0.05$).

Based on the dosimetric results, which are listed in Table 2, on the comparison between the two groups for PTV in terms of D_{min}, D_{mean}, D_{max}, HI, CI, and TCP, there is no statistically significant difference between the two groups ($p > 0.05$). Therefore, this means that the left arm-up position (group 1) is the same as the right arm-up position (group 2) in terms of dose distribution in PTV. The reason for this is that the position of the arms does not affect changing the position of PTV.

The heterogeneity index (HI) is approximately the same in both groups (Table 2), and no significant difference exists between the two groups ($p > 0.05$). For the conformity index (CI), a closer value of CI to the value of 1.00 indicates that PTV has high conformal coverage, and there is no statistically significant difference between the two groups ($p > 0.05$) in terms of CI. For TCP, there is no statistically significant difference between the two groups ($p > 0.05$). The reason for this is that changing the position of the arms does not change the dose, volume, or geometry or shape of PTV.

Comparison of two groups in terms of dose to OARs

As can be seen in Figure 5, all doses are below the tolerance dose for the heart, left lung, spinal cord, and thyroid. Especially for thyroid, there is a significant difference between the two groups ($p<0.05$).

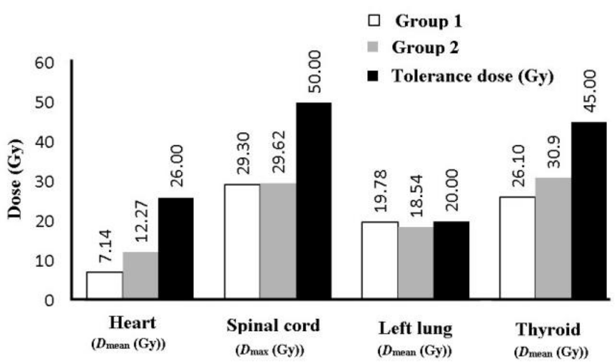

Figure 5. D_{mean} (Gy) for heart and left lung; D_{max} (Gy) for spinal cord; D_{mean} (Gy) for thyroid; and tolerance dose for left arm up position (group 1) and both arm up position (group 2)

To compare the two groups in terms of OARs, the results are listed in Table 2, D_{mean} for the heart is less than 26 Gy, when compared with the tolerance dose according to the study by Emami *et al.* [3]. There is also no difference between the two groups in terms of D_{min}, D_{mean}, D_{max}, and NTCP for the heart ($p >0.05$), when the results for the two groups are compared for the heart.

For the left lung, the results are presented in Table 2 for the two groups in terms of D_{min}, D_{mean}, D_{max}, V20 Gy (%), and NTCP. Based on this table, there is no statistically significant difference between the two groups ($p>0.05$) in terms of D_{min}, D_{mean}, D_{max}, V20 Gy (%), and NTCP. It was observed that the results in terms of V20 Gy (%) are higher than the tolerance dose (V20 Gy (%)<40%) based on the Emami report [4] and the reason for this is that clinically, while the physicists are trying to have the PTV by 95% of the dose, they are mandated to have the lung dose high in some patients. In other words, between covering PTV with good dose coverage and having a low dose for the lung, it's better to select the first option due to clinical reasons.

Based on the results in Table 2 for D_{min}, D_{mean}, D_{max}, and NTCP when comparing the two groups, there is no statistically significant difference between the two groups in terms of D_{mean} and NTCP ($p > 0.05$). The D_{max} is less than 50 Gy, which is the tolerance dose when comparing the D_{max} with the tolerance dose according to the Emami report [23].

For the thyroid (Table 2), all parameters, including Dmin, Dmean, and D_{max}, are less than 45 Gy, which is the tolerance dose according to the Emami report (23), and there is a statistically significant difference between the two groups ($p<0.05$), where the right arm up position (group 2) is better than the left arm up position (group 1) in terms of D_{min}, D_{mean}, and D_{max} because the position of the thyroid is different in the two groups due to head rotation differences. Since the irradiations included the supraclavicular fields as well, the arm position may have an effect on the radiation dose in the supraclavicular field, and the difference between the two groups in terms of the dose to OARs could be partially due to this effect.

4.1. Comparison of Results with other Studies

The following are some previous studies; the values in this study were close to those in the previous studies due to all these studies using 3DCRT with 6 MV photon beam energy on patients who underwent radiotherapy after BCS, using the prescribed dose of 50 Gy, to calculate the indicated values.

In a study by Kazemzadeh *et al.* [20], the aim was to use a radiobiological model to compare conventionally fractionated radiotherapy versus hypofractionated radiotherapy. They reported that the D_{mean} (Gy) for PTV was 51.40; CI was 0.89; TCP was 99.16% (listed in Table 3); NTCP for heart was 0.00%; V20 Gy (%) was 20.99% for lung; and NTCP was 0.09% for lung (listed in Table 4). These results are close to those of this study (Table 3 and Table 4). In a study by Chen *et al.* [24] (Table 3), IMRT was compared to 3DCRT, and the results were: CI was 0.33; D_{mean} (Gy) for the heart was 5.31 Gy; for the lung, 11.28 Gy; and V20 Gy (%) was 21.6% for the lung in Table 4. These results are close to those of this study (Table 2).

In a study by El-Mesidy *et al.* [25], the aim was to compare TCP and NTCP in 3DCRT and IMRT. The results of TCP were 65.90% (Table 3); V20 Gy (%) was 24.41% for lung (Table 4). These results are close to those of this study (Table 3 and Table 4).

In a study by Fiorentino *et al.* [26], the aim was to compare PTV and OARs between 3D-CRT and 4-fields in IMRT treatment plans. The results of D_{mean} (Gy) for the heart were 2.4 Gy (as listed in Table 4). This result agrees with this study (Table 4).

A study by Liu *et al.* [27] aimed to compare dosimetric differences between three types of plans based on a clinical dosimetric study for 3D-CRT, IMRT, and VMAT. The D_{mean} (Gy) for lung was 13.85 Gy; V20 Gy (%) was 29.45%; and the D_{mean} (Gy) for spinal cord was 8.07 Gy (as listed in Table 4). These results are in agreement with this study (Table 4).

In a study by Wei *et al.* [5], the aim was to evaluate the dosimetry differences between IMRT and 3D-CRT. The result of D_{mean} (Gy) for thyroid was 21.84 (as listed in Table 4). This result agrees with this study (Table 4).

Table 43. Dose distribution parameters (D_{mean} (Gy), CI, and TCP) in PTV in the present study and the previous studies with 3DCRT. The photon beam energy is 6 MV in these studies

Parameter	Left arm up	Both arms up	Value from previous studies	Reference
	Mean ±SD	Mean ± SD		
D_{mean} (Gy)	49.87±1.17	50.69±0.4	51.40 ± 0.71	Kazemzadeh, *et al.* [6]
CI	0.67±0.09	0.74±0.07	0.89 ± 0.03	Kazemzadeh, *et al.* [6]
TCP (%)	91.95±3.69	91.63±3.66	99.16 ± 0.09	Kazemzadeh, *et al.* [6]

Table 4. Dose distribution parameters (D_{mean} (Gy), NTCP, and $V_{20\ Gy}$ (%) for left lung) in OARs in the present study and the previous studies with 3D-CRT. The photon beam energy is 6 MV in these studies

OAR	Parameter	Left arm up	Both arms up	Value from previous studies	References
		Mean± SD	Mean ±SD		
Heart	D_{mean} (Gy)	12.36±4.32	7.73±4.88	5.31± 0.20	Chen, *et al.* [7]
	NTCP (%)	0.00±0.00	0.00±0.00	0.00	Kazemzadeh, *et al.* [6]
Left lung	D_{mean} (Gy)	18.68±5.77	19.78±1.13	13.85±1.1	Liu, *et al.* [8]
	$V_{20\ Gy}$ (%)	38.00±5.21	34.92±5.56	29.45±2.46	Liu, *et al.* [8]
				24.41±5.55	El-Mesidy, *et al.* [9]
	NTCP (%)	0.02±0.01	0.02±0.02	0.09 ± 0.06	Kazemzadeh *et al.* [6]
Spinal cord	D_{mean} (Gy)	3.94±1.30	6.06±4.65	8.07±1.45	Liu, *et al.* [8]
Thyroid	D_{mean} (Gy)	30.96±7.53	26.10±4.12	21.84 ± 7.47	Wei, *et al.* [5]

5. Conclusion

Based on the results obtained in the present study, the patient's arm positioning had almost no effect on the dose distribution in PTV in terms of D_{min}, D_{mean}, D_{max}, HI, CI, and TCP. For OARs, there was no statistically significant difference between the left arms up position (group 1) and both arms up position (group 2) for organs such as the heart, left lung, and spinal cord in terms of D_{min}, D_{mean}, D_{max}, and NTCP (p>0.05); however, there was a statistically significant difference for thyroid (p<0.05). In other words, the thyroid dose was higher in both arms-up position patients (group 2). Due to some clinical reasons, such as patient comfort for body and head position, and better accuracy due to the positioning of 9 markers. And the patients tend to curve their bodies to the opposite side (right side) in one arm position, positioning in group 2 is relatively better than positioning in group 1 for those clinical reasons, but the left arm position (group 1) is better in terms of dose distribution for the OARs such as thyroid.

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