Half Beam Technique in Patient with Left Breast Cancer and Evaluate its Dosimetry Parameters from Dose-volume Histograms

Nashwan K. Abdulkareem[1], Fatiheea F. Hassan[2]

[1]Lecturer, [2]Assistant Professor, Biophysics Unit, Department of Basic Science, College of Medicine, Hawler Medical University (HMU), Erbil, Kurdistan Region, Iraq

Abstract

Using of 3DCRT for the treatment of left breast cancer by a single isocenter with half beam in the junction of tangential and supraclavicular fields is an important method. The purpose was to evaluate the outcome of Radiation Treatment Plans (RTP) that includes planning target volume (PTV) dose, conformity index (CI), homogeneity index (HI), organs at risk (OAR), and compared with tolerance doses of left-sided whole breast irradiation by half beam technique. Thirteen patients with left breast cancer who had received radiotherapy by using 6, 10, and 18 MV photons. The clinical target volume [CTV] was contoured as a target volume, and left lung, right lung, heart, and spinal cord tissues as OAR planning technique was analyzed at Zhianawa cancer center (ZCC), Sulaimany-KR-Iraq. There was No risk for 12 patients CI (<1), accept patient No. (6) CI>1. the PTV was under coverage (4060±32.116 cGy), was close to 4005 Gy volume. The left lung, and right lung mean dose was (33.923, 1018.231cGy < tolerance mean Dose (4000 cGy), and for Lt lung Dose V20 < 30 cGy. Heart Dose V35 (2.354) <20Gy, and Heart mean Dose (cGy)Dose was (358.308 cGy) < tolerance mean Dose (2600 cGy). Cord Max dose was (682.692cGy) < 2000. the Dose mean value of esophagus was (29,077)cGy was <3400 (Esophagus Tolerance mean dose (cGy). The application of left breast cancer provides significant advantages especially in PTV and OAR dosages.

Keywords: *Radiotherapy, breast cancer, tolerance doses.*

Introduction

Three Dimensional Conformal Radiotherapy (3DCRT) technique is an external beam radiotherapy that can deliver more precise doses. (3D-CRT) consists of 3D images That are produced by (CT scan). The 3DCRT is able to shape the Radiotherapy Beam to closely match the tumor shape and size. Radiation is delivered by using irregular beams with homogeny intensity according to the target shape, which conforms with the irradiated volume of the target shape[1].

The supra-clavicular, internal mammary fields and tangents are set as half beams (use of asymmetric jaws) so that there is no divergence at the junction. Planning was set as supraclavicular area half beam. Table and collimator angles were not added to provide field overlap. The gantry angle was provided to extract the esophagus out of the field. In patients with location in the left breast[2]. The purpose of this study was to verify and evaluate between the outcome of Radiation Treatment Plans (RTP) of left-sided whole breast irradiation by half beam technique, to organs at risk (OAR) that included left lung, right lung, heart, and spinal cord by different numbers of beam in left sided breast. These were then compared with tolerance doses.

Corresponding Author:
Nashwan K. Abdulkareem
Lecturer, Biophysics Unit, Department of Basic Science, College of Medicine, Hawler Medical University (HMU), Erbil, Kurdistan Region, Iraq
e-mail: nashwan.abdulkareem@hmu.edu.krd

Material and Method

Patients: Thirteen patients with left-sided, breast carcinoma who had received radiotherapy were selected for this study. The dose prescriptions for the patients were different according to each patient's cancer stage.

Optima CT Scanner: Breast cancer treatment often uses Optima CT 580 RT (general electric Healthcare -USA) 80cm big bore CT-Scanner. This device is often employed in radiotherapy, with a flat RT couch[3,4].

Xio Treatment Planning System: Xio is a radiotherapy planning software system designed by CMS-Elekta for contouring, 3DCRT planning. All (pencil beam, convolution, and super position) algorithms can be used with Xio (Elekta Product. version 5.00.01)[5].

The Xio which used is predicated on a network of three main high performance computers (Quad-core Intel xeon 2.93GHz processor, 24GB DDR3 RAM, 4TB Storage) that is connected with the center's main network.

Elekta Synergy Linac: Elekta Synergy Linac (2013, UK) utilises three photon energies (6, 10 and 18MV) and 8 electron energies (4, 6, 8, 10, 12, 15, 18 and 22MeV). Each leaf is 1cm width and can access a maximum field size of 40x40 cm at SSD 100cm[5].

Method

Patient Selection: Radiotherapy using 3DCRT was used on thirteen patients with early-stage left-sided breast cancer. This study was performed on a linear accelerator machine type Elekta Synergy, 2013. The Elekta Synergy linac consists of 3 photon energies (6, 10, and 18MV).

Simulation: All patients underwent Computed Tomography (CT) simulation. The patients' left and right arms were positioned above their heads. Tattoos and markers were used during the pretreatment procedure. Scanning was performed in 2.5-mm slices from the clavicle to the mid-abdomen during free-breathing[6].

The Clinical Target Volume (CTV) for the tumor was contoured. Additionally, the Planning Target Volume (PTV) was constructed by adding 5-mm margins and editing 5-mm of the build-up region from the breast skin surface.

Plan Evaluation: In current radiation therapy, physical dose indices, such as isodose distribution charts and mean doses, (DVHs), are invariably employed for treatment plan evaluation.

DVH created for the planning method as well as several quantitative evaluation tools were reviewed for plan evaluation. These included target volume coverage, (HI), (CI), and OAR dose, maximum dose, mean dose by half beam technique and then compared with tolerance doses.

Conformity Index (CI): Conformity index (CI) is defined as the ratio between the volumes covered by a specific dose to the PTV volume. For this study, volumes that covered 95% of the approved doses were employed to estimate the CI values (Eq.: 1). Therefore, CI < 1 signifies that the PTV is under coverage. In contrast, CI > 1 denotes that normal body tissue is receiving an elevated dose. Where CI = 1 the prescribed dose is consistent with to PTV outline[6].

CI = (volume covered by 95% of prescribed dose)/(volume of PTV) ...1

Homogeneity Index (HI): Homogeneity Index (HI) is an empirical tool used to examine the consistency of a distribution dose in a target volume. The maximum dose (D2%) can be delivered to 2% of the PTV. Dp is the agreed dose for PTV, and D98% is the minimum dose calculated for the 98% of the PTV.

These parameters were used to calculate the HI using the Eq 2.

$$HI = (D_{(2\%)} - D_{(98\%)})/(D_p) \quad ...2$$

Lower HI denotes a beneficial uniform dose distribution that can be achieved in the target[7].

Results

From table (1 and 2); CI value indicates the degree of conformity of the plan. Therefore, above results indicates that (CI= 0.89±0.209) CI < 1 signifies that the PTV was under coverage. If CI > 1 denotes that the normal body tissue were receiving a substantial dose. Finally, CI = 1 indicates that the prescribed dose conformed to the shape of the PTV [8].

Lower HI means a better and more uniform dose distribution that can be achieved in the target[8].

Data obtained from Table (1, and 2) indicated that the conformity index (CI) of 3D-CRT for patient No. (6) was >1. This indicated that the normal tissue received a high dose. However, for the other 12 patients where CI < 1 this signified that the PTV was under coverage. All 3D plans significantly improved CI for 12 patients except patient No (6).

In general, 3D technique was more beneficial and with greater uniform dose distribution.

Table 1. The values of conformity index (CI) and homogeneity index (HI).

No. of the Patient	Half Beam Size		
	PTV Mean Dose (cGy) 4060±32.116	HI	CI
1	4104	0.20749	0.905485
2	4073	0.166821	0.949103
3	4097	0.208388	0.936251
4	4058	0.179553	0.515840
5	4021	0.179903	0.919338
6	4068	0.218250	1.339031
7	4057	0.187193	0.945477
8	4039	0.167095	0.949424
9	4095	0.374485	0.976303
10	3987	0.453851	0.913427
11	4067	0.196954	0.516054
12	4049	0.200499	0.754823
13	4072	0.175484	0.950828
Mean±SD	4060±32.116	0.224±6.087	0.89±0.209

Table 2. Dose homogeneity (HI) value, and Conformity Index (CI) value.

		No	%
CI for PTV 3D	No risk (<1)	12	92.3
	High risk (>1)	1	7.7
	Perfect (=1)	-	-

Table 3. Mean dose value delivered to the Right-Lung (Rt-lung).

No. of the Patient	Rt-Lung Mean Dose (cGy		
	Half beam mean dose	V20<30	Tolerance mean Dose cGy <4000
1	23	0	<4000
2	25	0	<4000
3	22	0	<4000
4	41	0	<4000
5	27	0	<4000
6	123	0	<4000
7	31	0	<4000
8	37	0	<4000
9	18	0	<4000
10	21	0	<4000
11	16	0	<4000
12	31	0	<4000
13	26	0	<4000
Mean±SD	33.923± 27.696	0±0	

Data from tables 3; The received mean dose volume of the Right lung (Rt-lung) was (33.923±27.696cGy), and Rt Lung Tolerance mean dose (cGy) was <4000 cGy. Also V20<30 Gy, this was since the Rt lung was distant from the target.

Table 4. Mean dose value delivered to the Left-Lung (Lt-lung).

No. of the Patient	Lt lung mean Dose (cGy)		
	Half beam mean dose	V20<30	Tolerance mean Dose <4000
1	893	17.32	<4000
2	1115	21.53	<4000
3	1152	26.82	<4000
4	853	20.17	<4000
5	1191	28.31	<4000
6	1064	23.92	<4000
7	1392	19.68	<4000
8	642	9.81	<4000
9	484	9.91	<4000
10	1104	25.75	<4000
11	755	16.64	<4000
12	1392	30.35	<4000
13	1200	27.43	<4000
Mean±SD	1018.231±276.621	21.357± 6.639	

In the present study from table 4; the low dose volume (<30Gy) for the left lung was (21.357±6.639cGy) and the low dose volume V20 <30Gy. The Left Lung (Lt-lung) Mean Dose (cGy) (1018.231±276.621).

Table 5. Mean dose value delivered to heart of 13 patients in half beam techniques

No. of the Patient	Heart mean Dose (cGy)		
	Half beam mean Dose cGy	V35<20 Gy	Mean Dose < 2600
1	259	0.16	<2600
2	518	2.35	<2600
3	370	2.94	<2600
4	199	0.02	<2600
5	759	10.11	<2600
6	393	2.78	<2600
7	462	3.14	<2600
8	213	0.09	<2600
9	362	2.34	<2600
10	191	0.32	<2600
11	191	0.37	<2600
12	462	3.77	<2600
13	279	2.21	<2600
Mean±SD	358.308±165.213	2.354±6.639	

The quantitative data obtained from Table 5 showed that the mean dose to the heart was (358.308±165.213), which was <2600 cGy.

The result indicated that the heart was exposed to doses (2.354±6.639) <20 Gy. The low dose volume for(V35)was <20Gy. However, we found that there was no absolute safe dose. Our finding concurs with (Taylor et al, 2009)[8], who found that adjuvant RT to left sided breast cancers had a small but significant increase in the risk of both cerebrovascular and cardiac deaths.

Table 6. Max dose value delivered to spinal cord and Mean dose value delivered to esophagus

No. of the Patient	Cord Max. Dose (cGy)	Cord Tolerance	Esophagus
	Half Beam Max Dose	Max. Dose (cGy< 2000	Mean Dose Value (cGy)
1	788	<2000	25
2	283	<2000	27
3	1244	<2000	38
4	1456	<2000	36
5	819	<2000	52
6	538	<2000	20
7	594	<2000	39
8	149	<2000	13
9	22	<2000	18
10	922	<2000	34
11	30	<2000	20
12	1112	<2000	39
13	918	<2000	17
Mean±SD	682.692±463.284		29,077±11.5

Table 6. indicates that Cord max dose was (682.692±463.284cGy)< 2000 cGy. And Spinal cord max dose was <45Gy (4500 cGy), which coincides with (Majumder et al, 2014) [9]. From data in table 6, the Dmean value of esophagus was (29,077±11.5)cGy <3400 (Esophagus Tolerance mean dose (cGy)).

Discussion

Breast radiotherapy is a prevalent type of radiotherapy procedure. Breast cancer poses a serious health threat to much of the human population. Breast cancer alone is the most widespread form of female carcinoma. By this commonly the use of 3D planning offers better dose homogenization with considerable decrease in skin toxicity while minimizing the radiation dose received by normal organs. In this study, PTV max and PTV mean values obtained by single isocenter with half beam use were proximal to the planned values while overdose was minimal. PTV was in half beam technique (4060±32.116 cGy).

The aim of 3DCRT that employs single isocenter with half beam is to produce an equal dose distribution during treatment. Concomitantly, the technique attempts to minimize radiation exposure in the esophagus, ipsilateral lung, spinal cord and heart. Quantitative data were considered from the DVHs and were based on three significant factors: PTV dose, conformity index (CI), and homogeneity index (HI). The D2% represented the maximum dose delivered to 2% of the PTV for all 13 patients, and D98% was the minimum dose calculated for 98% of the PTV. The prescribed dose received by 95% of the PTV assisted in the evaluation of the dosimetry plans. A minimal amount of HI indicated that a lesser dose exceeded the prescription dose. in this study, a minimum HI had better dose uniformity than other patients

Dose conformity was measured by CI. CI value indicates the degree of conformity of the plan.

The CI measures the degree of conformity, which is calculated as follows[7]:

- CI value indicates the conformity degree of the plan. If CI < 1, the PTV is under coverage.

- If CI > 1, the normal tissues receive a high dose.
- Lastly, if CI = 1, in this case, the prescribed dose conforms to the PTV shape.

CI = (volume covered by 95% of the prescribed dose)/(volume of PTV) (10).

Data obtained from table 1; indicated that the PTV was under coverage because CI < 1 for 13 patients except patient number(6).

Lungs are one of the first organs to receive radiation beam and to be protected during breast radiation[10]. However, half beam technique is statistically significant on right lung (Rt-lung) via reduction of V5 in <5 Gy. In this study, there while was a decrease in V20, V30, and D- mean values they did not reach statistical significance.

In half beam techniques satisfied the objective for V5Gy, V20Gy and V30Gy for Left lung (Lt-lung). The lowest V20Gy were found with half beam (21.357±6.639) .

In general, Our results showed that both V5 Gy, V20Gy, V30Gy, D- mean values, and Dmax were significantly higher in Left lung (Lt-lung) than Right lung(Rt-lung) in both techniques, due to the location of Left lung which was proximal to the target area.

In relation to the heart, the objective V35<20GY or (2000 cGy) was achieved in half beam technique. Clinical effects of radiation induced heart disease have been observed with therapeutic doses of >35 Gy to partial volumes of the heart.

Risks to the left breast tend to be increased during radiotherapy. Factors such as age gender, lifestyle, obesity and hypertension, among others significantly increase Even when these aforementioned factors are taken into consideration, radiation dose to the heart is still considered as being the most important factor[11]. Table 6 Showed that max dose for the spinal cord in half beam was (682.692±463.284cGy). In half beam technique the spinal cord max dose <45 Gy. This finding corresponds with (Majumer et al, 2014)[9].

Conclusions and Suggestions

A plan should ideally produce a steep curve showing that the dose within the PTV is constant; albeit, the dose between 95% - 107% of PTV varies according to the International Commission on Radiation Units and measurements ICRU50.

Any radiation dose may increase the risk of a second malignancy. In principle, the irradiated volume should be as minimal as possible. The 3DCRT with half beam technique achieved a significant reduction in the volume of heart and ipsilateral lung exposed to high-dose (≤40.05 Gy). In general, these techniques may benefit patients with heart disease, and wherever cardiac regions are exposed to doses <20 Gy, irrespective of the selected plan. Heart and lung are the primary organs of concern. In this study when using half beam, the relative volume of ipsilateral lung or heart receiving high-dose (40.05Gy) was significantly reduced. The relative volume of bilateral lungs and heart receive even a lower dose (5 Gy) was increased.

In a radiotherapy center like (ZCC), where a limited number of RT machines and requirements are available for hundreds of patients in the waiting list, it is necessary to take into consideration the required delivery time, as well as improvement in the target coverage and OARs sparing, when selecting an available treatment method. The dose was prescribed for all PTVs according to the type, size, and location of the tumor for each patient.

Recommendations:

1. We recommended using other 3DCRT with half beam technique in Zhianawa Center that they reduce the risk of induce second cancers.
2. Based on the results, one isocentric in half beam with wedge technique provides significant advantages in

Conflict of Interest: Not

Ethical Clearance: The study was approved by the Ethics Committee of the College of Medicine, Hawler Medical University, Kurdistan Region, Iraq.

Source of Funding: Myself

References

1. Veronesi U, Cascinelli N, Mariani L, Greco M, Saccozzi R, Luini A, Aguilar M, Marubini E. Twenty-year follow-up of a randomized study comparing breast-conserving surgery with radical mastectomy for early breast cancer. New England Journal of Medicine. 2002 Oct 17;347(16):1227-32.
2. Kagkiouzis J, Platoni K, Kantzou I, Dilvoi M, Patatoukas G, Kypraiou E, Efstathopoulos E, Sarris G, Trogkanis N, Kouloulias V. Review of the three-field techniques in breast cancer radiotherapy. J

BUON. 2017 May 1;22:599-605.

3. Gagliardi G, Constine LS, Moiseenko V, Correa C, Pierce LJ, Allen AM, Marks LB. Radiation dose–volume effects in the heart. International Journal of Radiation Oncology* Biology* Physics. 2010 Mar 1;76(3):S77-85.
4. Inc. XiO® is a registered trademark of IMPAC Medical System. Revision LUGXIO0470 in 2015.
5. Elekta Product. XiO Treatment Planning System TPS (version 5.00.01, Elekta AB, Stockholm, Sweden).
6. Knöös T, Kristensen I, Nilsson P. Volumetric and dosimetric evaluation of radiation treatment plans: radiation conformity index. International Journal of Radiation Oncology* Biology* Physics. 1998 Dec 1;42(5):1169-76.
7. Yoon KS, Duncan T, Lee SW, Scarloss B, Shapley KL. Reviewing the Evidence on How Teacher Professional Development Affects Student Achievement. Issues & Answers. REL 2007-No. 033. Regional Educational Laboratory Southwest (NJ1). 2007 Oct.
8. Taylor CW, McGale P, Povall JM, Thomas E, Kumar S, Dodwell D, Darby SC. Estimating cardiac exposure from breast cancer radiotherapy in clinical practice. International Journal of Radiation Oncology* Biology* Physics. 2009 Mar 15;73(4):1061-8.
9. Majumder D, Patra NB, Chatterjee D, Mallick SK, Kabasi AK, Majumder A. Prescribed dose versus calculated dose of spinal cord in standard head and neck irradiation assessed by 3-D plan. South Asian journal of cancer. 2014 Jan;3(1):22.
10. Petrova D, Smickovska S, Lazarevska E. Conformity index and homogeneity index of the postoperative whole breast radiotherapy. Open access Macedonian journal of medical sciences. 2017 Oct 15;5(6):736.
11. Gagliardi G, Constine LS, Moiseenko V, Correa C, Pierce LJ, Allen AM, Marks LB. Radiation dose–volume effects in the heart. International Journal of Radiation Oncology* Biology* Physics. 2010 Mar 1;76(3):S77-85.