International Journal on Emerging Technologies **11**(1): 447-453(2020)

ISSN No. (Print): 0975-8364
ISSN No. (Online): 2249-3255

Comparative Study of Effectiveness of Peripheral Dose of Linear Accelerator Beam on Organs near the Radiotherapy Field Edge in Complete and Half Field Size X-ray Beam Techniques

Nashwan K. Abdulkareem[1] and Fatiheea F. Hassan[1]
[1]Biophysics Unit, Department of Basic Science, College of Medicine,
Hawler Medical University (HMU), Erbil, Kurdistan Region, Iraq.

(Corresponding author: Nashwan K. Abdulkareem)
(Received 14 November 2019, Revised 27 December 2019, Accepted 04 January 2020)
(Published by Research Trend, Website: www.researchtrend.net)

ABSTRACT: Three-dimensional conformal radiotherapy 3DCRT used to deliver precise dose for breast cancer. This study compared the effect of peripheral dose by two treatment planning techniques: complete beam and half beam on planning target volume, homogeneity dose, and doses of heart, Right Lung, Left Lung, homogeneity, and conformity index in the target region. Fifty women with left breast cancer were included in this study. 3DCRT was used to produce maximum dose to target volume coverage, minimum dose to healthy tissues, two techniques used for supraclavicular area, whole breast area, with a single isocenter. Mean dose Gy for PTV was lower in complete beam than half beam (40.53 vs 41.44Gy, respectively; p<0.006). The prescribed dose for the two methods was 40.050Gy and complete technique was more uniform dose distribution than half. No significant difference was noted by two techniques in CI both <1. Mean heart dose was significantly improved in complete compared to half (4.76 vs. 3.73Gy, p< 0.003). Both techniques showed heart dose exposure <2.6 Gy. Similarly, the Left Lung V20 values were significantly better in half beam than complete beam (20.1 vs. 20.8 Gy respectively; p <0.465), and There was insignificant difference between the complete and half technique. The mean dose of the Left Lung was significantly lower for complete compared to half beam (10.81 vs. 10.19 Gy respectively; p<0.003), but with the right lung was significantly lower for half compared to complete beam (88.2 vs. 29.4, respectively; p<0.001). Complete planning treatment showed better homogeneity compared to the half beam plans.

Keywords: breast cancer, field matching, junction, radiotherapy, supraclavicular.

I. INTRODUCTION

Radiation therapy is the medical use of ionizing radiation as part of cancer treatment to control malignant cells in the human body. Radiotherapy is one of the three principal modalities used in to treat malignant disease such as breast cancer. The other two methods are surgery and chemotherapy. Modern oncology, according to each case, combines the three methods in order to attain the best result for each treatment. Hence, radiation therapy may be used as the primary treatment for breast cancer [1]. External Beam Radiation Therapy (EBRT) is the most common type of radiation used to treat breast cancer. Three-dimensional conformal radiotherapy (3DCRT) uses multiple radiation fields with precision while sparing normal tissue. 3DCRT/quadrant breast irradiation delivers radiation to a minimal portion of the breast. Multiple, targeted beams reduce the chances for irradiation of critical organs such as heart and lungs [2-4]. Generally, during radiotherapy for breast cancer, a percentage of the prescribed dose that is delivered to the target volume (breast cancer) is absorbed by organs outside the radiation field such as heart, spinal cord, esophagus, and lungs. These organs may lie close to the radiation field, or remotely from it. This amount of dose is called peripheral dose Peripheral Dose (PD).

Peripheral Dose (PD) is the radiation dose received at points beyond the collimated radiotherapy field edge. In order to ensure that radiosensitive structures outside the treatment field do not receive doses approaching their tolerance levels, extensive knowledge of the magnitude and spatial distribution of the Peripheral dose (PD) may be necessary. Since there is no dose that is regarded as safe, assessment of peripheral doses (PD) to radiosensitive tissue/organs, such as the breast, the gonads and the thyroid, are essential to determine the possible risk of late effects, such as secondary cancers that could appear in long-term surviving patients [5]. Therefore in this study we have attempted to a apply new technique that can prevent or reduce peripheral dose to radiosensitive organs by using technique with two contrastive indirect fields. Irradiation is necessary where needed to lymph nodes in the supraclavicular region.

This includes an anterior third of these mentioned nodes. Three-field methods incorporated in this study can be separated in a sole isocenter (monoisocentric) method in complete half and field techniques. Three-field harmonizing is complex, with potential for excess or under dosage in the converging area. Several methods have been discussed, each having certain merits and problems, including monoisocentric methods where relevant. Use of a single isocenter for all three fields is the main characteristic of this study. The isocenter is placed in the junction of tangential and supraclavicular fields Fig. 1.

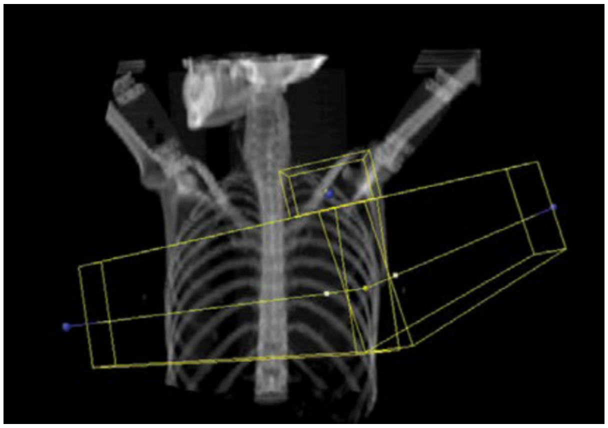

Fig. 1. Full-field technique for irradiation of tangential breast fields and supraclavicular field [5].

The upper half of the tangential fields and the lower half of the anterior field are half-blocked, using blocks or MLCs [7]. Difficulties with field junction dosimetric problems solvable via virtual simulation. Sometimes, treatment of breast lymph nodes by multiple adjacent fields may cause cold and hot areas within at filed junctions (Fig. 2).

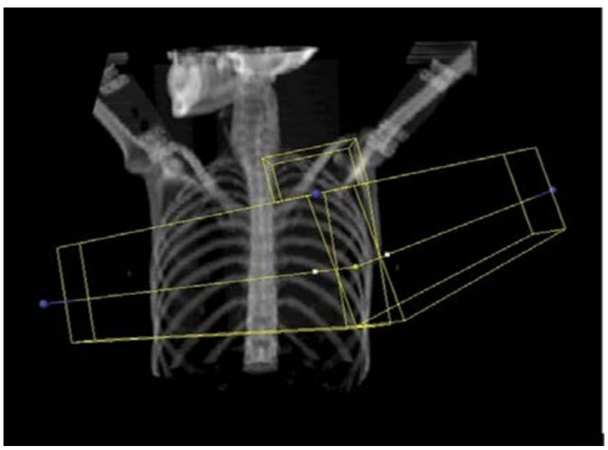

Fig. 2. Half-field technique for irradiation of tangential breast fields and supraclavicular field [5].

In order to solve this issue asymmetric jaws which produce a half beam for the supraclavicular field are used. This utilises couch rotations which align the tangents' superior border to the inferior border of the supraclavicular field. Unfortunately, this increases patient set up problems for technologists. For treating each volume the treatment couch needs to be modulated for it to move smoothly between beams [5]. A novel and precise isocenter can be established between the breast tangents and supraclavicular fields [6]. In order to omit the possibility of junction divergence the internal mammary and supraclavicular fields need to be established as half beans by using asymmetric jaws. Correct positioning of dose points in each volume act as prescription sites and normalization.
Tangential field Techniques with Half Beam (Full Beam symmetric field for breast case as in Fig. 3(a), and half beam (by block other half) treatment setup as in Fig. 3(b) [7].

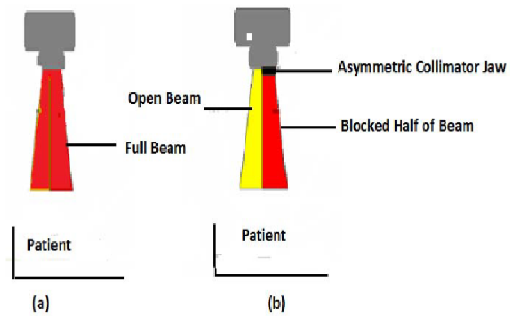

Fig. 3. (a) Full Beam Technique for breast patents (b) Half Beam Technique [7].

II. PATIENTS AND METHODS

A. Study design
In this comparative study, 50 patients with early stage left-sided breast cancer were treated with radiation therapy using 3DCRT. This study was performed on an Elekta Synergy linac, 2013, from the United Kingdom. The Elekta Synergy linac consists of 3 photon energies (6, 10 and 18 MV) and 8 electron energies (4, 6, 8, 10, 12, 15, 18 and 22 MeV). The accelerator machine is equipped with Multi-Leaf Collimator (MLC) at the Zhianawa Cancer Center (ZCC) KR, from October 2016 to June 2019.

B. Computed Tomography Scan (CT scan)
Optima CT 580 RT (general electric Healthcare -USA) 80cm big bore CT-Scanner used for radiotherapy with flat RT couch. Optima 580 is a 16 slice scanner (it takes 16 slices in one gantry rotation), By a computed tomography (CT) scan can look inside the body (Fig. 4) [8].

Fig. 4. GE Optima 580 CT scanner [8].

C. XiO planning system
The used radiotherapy planning system software(Xio) designed by CMS-Elekta for contouring, 3D-CRT planning. It is able to evaluate 3D dose distribution and correction for in homogeneity. All (pencil beam, convolution, and super position) algorithms can be used with Xio (Elekta Product. version 5.00.01).
The used Xio planning systems version was 5.00.02, which needs a network of three main high performance

computers (Quad-core Intel xeon 2.93 GHz processor, 24GB DDR3 RAM, 4TB Storage) [9].

D. MOSAIQ Software

MOSAIQ by Elekta is an ONC-ATCB (The Office of the National Coordinator for Health Information Technology -Authorized Testing and Certification Body) certified electronic medical record and verification (EMRV) and practice management system, were used by oncology specialists. Modules include medical billing, delivery, treatment planning and patient information management system practice management. A benefit of MOSAIQ is consent and upgrade of work spaces. MOSAIQ is a versatile program which can create reports, templates, integrating diverse data, electronic charts and images [10].

E. Linear accelerator (Linac) of Elekta apparatus

A device known as a Linear accelerator (LINAC) is a standard external beam radiation treatment method for cancer patients [1]. LINAC can be used for all anatomical structures, where it can deliver a high energy beam to a tumor. Its mechanism of action is by accelerating electrons in a linear line. In order to achieve this, a radio frequency (RF) is deployed using 10 cm wavelengths [1]. A designed vacuum like structure called a magnetron or an RF oscillator also known as a klystron, generates radio waves. The magnetron produces a powerful magnetic field. Measurements for this study were performed by the Elekta synergy Linear accelerator. This accelerator can generate three photon energies (6, 10 and 18 MV) and eight electron energies (4, 6, 8, 10, 12, 15, 18 and 22 Mev). Fig. 5 [11].

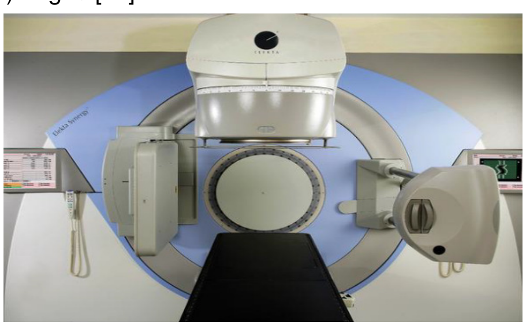

Fig. 5. Linear accelerator [11].

F. Method

The present study was conducted following the approval by the Ethical Committee of Hawler Medical University (KR, meeting code: 6, paper code: 8, date: 23/04/2016)

Computed tomography scan (CT scan) utilizes a combination of several X-ray measurements obtained from different angles which have been processed by computer to generate virtual "slices" of a specified object, thus, let the user to observe interior parts of the object, without the need for cutting. All patients underwent for simulation by computed tomography (CT) in the same treatment position. Using a computer to process a combination of X-rays, CT can produce pictures of human interior organs. It provides pictures with more detail compared to a regular X-ray. The obtained data from CT can be manipulated to show various structures inside body based on their capability in attracting the X-ray beams. Modern scanners have the ability to represent these data in various planes, or even produce volumetric three dimensional (3D) pictures of structures [8]. The planning target volume will provide the initial gross tumor volume (GTV) as well as provide a margin around the CTV to compensate for the variability of treatment setup. The GTV was specified as the gross volume of the tumor, while the CTV was defined to include both GTV and possible microscopic spreads along the routes.

Also, planning target volume (PTV) was decided as CTV with a undeviating border, so that include both the organ motions and set-up errors. Parotids and spinal cord were landmarked on all CT images as organs-at-risk (OAR's).

The treatment plan for each patient was established by the use of a XIO planning system superposition algorithm, and 6, 10, 18 MV photon beams provided by an ELEKTA Synergy linear accelerator, equipped with a multi-leaf collimators (MLC), having 80-leaf with 1 cm width projected at the isocenter. A dose of 40.05 Gy, 2.025 Gy per fraction, 5 fractions per week during four weeks (duration of treatment) to a reference point in PTV was prescribed, which satisfies most recommendations of International Commission of Radiation Units (ICRU). A region which was clinically relevant to PTV and had a low dose gradient was selected as the reference point. In order to control dose homogeneity, some additional dose points in PTV were considered [12].

G. Simulation

Computed Tomography (CT) simulation was used for all patients. CT incorporated a scanner capable of producing 16 arrays (Light Speed Xtra; general electric GE Healthcare, Waukesha, WI, USA). During CT patients were placed in a supine position. During the CT process tattoos and markers were measured for patients. A scan was conducted during respiration from the mid-abdomen to the clavicle using 2.5-mm slices [13]. The clinical target volume was established via delineating the ipsilateral whole breast. A 5-mm margin was constructed by adding the Planning Target Volume (PTV) and by editing of the 5-mm breast skin surface buildup region. Oppositional tangential fields were established without wedges, and optimized gantry angles were set up.

Two cm margin leaf were added to one side of the skin, and 3 mm to the other side. For each patient a reference point is defined for radiation beams. The reference point is located at the level between pectoralis major muscle and the breast nipple.

The target volumes were delineated according to the recommendation of ICRU, report No. 50. GTV was contoured according to the information from CT-Scanner, MRI, pathology, and oncology reports. PTV was delineated after CTV. Healthy tissues and nearby organs were contoured (spinal cord, Left lung(Lt lung), Right lung (Rt lung), heart, and esophagus) as OARs. CTV included tumor volume, as well as Lt lung, Rt lung, heart, and spinal cord tissues as OARs (Fig 4). The lungs were automatically delineated on CT scans [14]. The dose was prescribed for all PTVs according to the type, size, and location of the tumor for each patient. Dose prescription and delineation processes were conducted by radiation oncologists at ZCC. Dose limitation for the OARs is defined as: D30% was for the Lt lung and Rt lung (equivalent V20%); it is defined as the dose received by 30% of Lt lung and must be <20Gy to avoid pneumonitis. The prescribed dose by the oncologist was 40.050Gy/(2.670Gy/fraction), and the number of fractions was 15. These fractions are based on guidelines from the International Commission of Radiation Units and Measurement (ICRU), report 50 and 62 [14].

H. Comparison of Plans

In this study 3D-CRT have attempted to a apply two techniques that can prevent or reduce peripheral dose to radiosensitive organs by using two techniques :

– First, complete beam, Full-field technique (consisted of 2 opposing wedged tangential fields) for irradiation of tangential breast fields and supraclavicular field with two opposing tangential fields. It is necessary to irradiate supraclavicular lymph nodes where needed, by applying the third anterior field.

– The tangential breast fields are geometrically matched with the supraclavicular field by rotating the collimator and couch. The full-field length can be utilized for the tangential fields. With a single isocenter, the treatment delivery requires only one setup, thereby treatment time is significantly

– Second, Single isocenter, supraclavicular area half, breast half beam: Planning was set as supraclavicular area half beam, and tangential field half beam

Both plans were determined by the application of superposition algorithm which used the heterogeneity rectification XiO Planning System version 5.0 (Elekta AB). The PTV approved dose was 40.05 Gy in 20 fractions. The optimization constraint requires a minimum of 95% isodose line which incorporates 95% of PTV (V95%, volume receiving ≥95% of the approved dose, ≥ 40.05 Gy). The level of statistical significance was established at a p value of <0.05 for all tests. The Elekta Synergy® S linear accelerator with (6, 10, 18 MV) photon energy was used.

I. Plan evaluation

Plan evaluation was posited on various dosimetry parameters consisting of dose-volume histograms: conformity index (CI), homogeneity index (HI) which abide to the definition proposed by Report 83-2010 and the ICRU (vol. 10, and, respectively based on the following: Homogeneity Index (HI) is an objective tool that analyses the uniformity of dose distribution in the target volume [15]. The values of D2% and D98% for PTVs were obtained from DVH. D2% represents the maximum dose that is delivered to 2% of the PTV. Dp is the prescribed dose for PTV, and D98% is the minimum dose calculated for 98% of the PTV. The lower the HI, the better the dose homogeneity.

HI = (D-(2%)- D-(98%)/ (D-p)

The CI measures the degree of conformity, which is calculated as follows [16].

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) [16].

III. RESULTS

A. Demographic data

Fifty patients with early-stage left-sided breast cancer were included in this study. The age of patients was between 35-65 years. The mean PTV of all patients with complete beam technique was 4053.4 cGy (±46.0), and with half beam technique was 4144.3 cGy(±205.9). Previous biopsy, histopathology report, CT-Scan report, oncologist report, as well as all information about the patient like cancer type and stage, were taken into account for dose prescription by radiation oncologists. The role of medical physicists is to implement ideal planning to distribute the dose prescribed for the target area and reduce the dose received by healthy tissue. (Note; The SI unit for absorbed dose is the gray (Gy). Thus, the relationship between gray and rad is: 1 Gy = 100 rad or 100 cGy)

B. PTV

A summary of DVH analysis can be found in Table 1, where mean values over the cohort of fifty patients are reported together with their standard deviation.

Table 1: Mean ± SD (Range) for the values of Conformity Index (CI) and Homogeneity Index (HI) in both techniques complete and half beam size for all 50 patients.

		No.	Mean±SD (Range)
PTV Mean Dose (cGy) Complete Beam		50	4053.4±46.0 (3960-4163)
Half Beam		50	4144.3±205.9 (3987-4987)
Difference (Complete from Half)		50	-90.9±223.89
Difference%			-2.27±5.60 (-25.46 - 3.15)
95% CI of the Difference			(-154.5 - -27.27)
P value			0.006*
HI Complete		50	0.2±0.1 (0.1-0.4)
HI Half		50	0.2±0.1 (0.2-0.5)
Difference (Complete from Half)		50	-0.017±0.108
Difference%			-23.45±57.93 (-286.78 - 56.39)
95% CI of the Difference			(-0.048 - 0.014)
P value			0.273
CI Complete		50	0.9±0.2 (0.6-1.4)
CI Half		50	0.9±0.2 (0.5-1.3)
Difference (Complete from Half)		50	0.038±0.212
Difference%			1.14±25.62 (-65.95 - 47.03)
95% CI of the Difference			(-0.023 - 0.098)
P value			0.216
PTV Tolerance mean dose (cGy) <4005	<4005	50	

As shown in Table, compared between complete beam, and half beam plans showed the relative volume of PTV was significantly greater in half beam technique than complete(4144.3±205.9, 4053.4±46.0 cGy) respectively; P<0.006. The use of both techniques on the fifty patients had the PTV95% coverage values of >95% of prescription dose. This result corresponds with Abo-Madyan [17]. As shown in Table 1, dose homogeneity was measured by HI, and it indicated a more homogeneous dose distribution in PTV for patients that treated with complete beam compared with half beam (The lower the HI, the optimal the dose homogeneity). According to Table 1 results, HI was slightly improved with complete beam than half beam (0.200 vs. 0.217, p<0.273). Lower HI means a better and more uniform dose distribution that can be achieved in the target [18].

Table 2: Dose homogeneity (HI) value, and Conformity Index (CI) value, in 50 patients with complete beam and half beam.

		No.	%
CI for PTV complete	No risk (<1)	45	90.0
	High risk (>1)	5	10.0
	Perfect (=1)	—	—
CI for PTV half	No risk (<1)	47	94.0
	High risk (>1)	3	6.0
	Perfect (=0)	0	0

Dose conformity was measured by CI. CI value indicates the degree of conformity of the plan. Therefore, where CI<1 this denotes that the PTV was under coverage. Where CI>1 this meant that the normal tissues were receiving a high dose. Finally, where CI = 1 this indicates that the prescribed dose conformed to the shape of the PTV [18]. Data obtained from Table 2; indicated that the conformity index (CI) for five patients was>1. This indicated that the normal tissue received a high dose. However, for the other patients where CI < 1 this signified that the PTV was under coverage. And data from Table 2; indicated that the conformity index (CI) of these patients who was >1. This indicated that the normal tissue received a high dose. However, for the other patients where CI < 1 this signified that the PTV was under coverage. Data from Table 1; indicated that CI was slightly improved with complete beam than half beam (0.926 vs. 0.889 cGy, p<0.216).

C. Right lung (Rt-lung)

Table 3: Mean±SD (Range) for the values of Mean dose delivered to the Right-Lung (Rt-lung) of 50 patients in both technique complete and half beams size.

		No.	Mean±SD (Range)
Rt Lung Mean Dose (cGy) Complete Beam		50	88.2±119.6 (26-627)
Half Beam		50	29.4±20.5 (16-123)
Difference (Complete from Half)		50	58.88±114.33
Difference%			52.29±26.84 (-27.59 - 95.06)
95% CI of the Difference			(26.39-91.37)
P value			0.001*
V20<30 Complete		50	0±
V20<30 Half		50	0±
Difference (Complete from Half)			0±
Difference%			0±
Rt Lung Tolerance mean dose (cGy) <4000	<4000	50	

Data from Table 3; The received mean dose volume of the Right lung (Rt-lung) by complete beam higher than half beam was (88.2±119.6, 29.4±20.5 cGy, p<0.001), and in both techniques Rt Lung Tolerance mean dose (cGy) was <4000 cGy. This was since the Rt lung was distant from the target.

D. Left lung (Lt-lung)

Table 4: Mean ± D (Range) for the values of Mean dose delivered to the Left-Lung (Lt-lung) of 50 patients in both technique complete and half beams size.

		No.	Mean±SD (Range)
Lt Lung Mean Dose (cGy) Complete Beam		50	1081.8±313.6 (442-1751)
Half Beam		50	1019.3±268.5 (484-1462)
Difference (Complete from Half)		50	62.48±141.95
Difference%			3.86±18.47 (-102.04 - 25.34)
95% CI of the Difference			(22.14-102.82)
P value			0.003*
V20<30 Complete		50	20.1±5.3 (8.1-29.6)
V20<30 Half		50	20.8±5.7 (8.7-30.4)
Difference (Complete from Half)		50	-0.746±7.16
Difference%			-12.37±50.83 (-234.92 - 68.29)
95% CI of the Difference			(-2.78 - 1.29)
P value			0.465
Lt Lung Tolerance mean dose (cGy) <4000	<4000	50	

In the present study from Table 4; the low dose volume (<30Gy) for the left lung with complete beam was significantly higher than half beam (1081.8, 1019.3 cGy, p<0.003) and the low dose volume both of two techniques (V20) <30Gy. The Left Lung (Lt-lung) Mean Dose (cGy) for complete beam lower than half beam (20.1, 20.8, P<0.465).

E. Heart

Table 5: Mean ± SD (Range) for the values of Mean dose delivered to the heart of 50 patients in both technique complete and half beams size.

		No.	Mean±SD (Range)
Heart Mean Dose (cGy) Complete Beam		50	476.7±314.6 (201-1813)
Half Beam		50	373.8±188.5 (189-1015)
Difference (Complete from Half)		50	102.8±233.98
Difference%			14.74±17.76 (-20.03 - 80.75)
95% CI of the Difference			(36.33-169.32)
P value			0.003*
V35<20 Complete		50	4.4±4.5 (0-19.8)
V35<20 Half		50	2.2±2.1 (0-10.1)
Difference (Complete from Half)		50	2.29±3.57
Difference%			22.11±108.46 (-640.00 - 99.55)
95% CI of the Difference			(1.277-3.31)
P value			0.0001*
Heart Tolerance mean dose (cGy) <2600	<2600	50	

The quantitative data obtained from Table 5 showed that the mean dose to the heart with complete beam, and half beam was (476.7, 373.8 cGy, $p<0.003$), which in both techniques was <2600 cGy.
The result indicated that the heart was exposed to doses in both techniques (complete beam, and half beam) (4.4, 2.2 Gy) <20 Gy. The low dose volume in both two techniques (V35) <20Gy. However, we found that there was no absolute safe dose. Our finding concurs with Taylor, [19], 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.

IV. DISCUSSION

Breast cancer is a prevalent form of carcinoma which results in significant morbidity and mortality. Breast radiotherapy (a radiotherapy method) is a fundamental treatment method. 3D planning is often utilized in order to improve dose homogenisation at a significantly reduced dose to internal organ and skin. Ideally, each patient is provided with an optimum plan for treating cancerous breast tissue while reducing radiation risk to OARs. Of course, breast cancer treatments vary for each patient based on available technology, planning methods, and body geometry. In this study, PTV mean and PTV max values were delineated by single isometer based on two methods: complete beam and half beam that were proximal to the planned values while reducing the risk of radiation overdose.
PTV was significantly greater in half beam technique than complete (4144.3±205.9, 4053.4±46.0cGy) respectively; $P<0.006$. The aim of 3DCR by using single isocenter with two techniques; complete beam, and half beam is to generate the homogeneity dose distribution for breast cancer, as well as to achieve a marked decrease in volumes of heart, ipsilateral lung. Cumulative DVHs were assessed according to their target volumes and healthy tissues. 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 fifty 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. The dosimetry plan in this study aimed to cover at least 95% of the PTV. The results showed that the small amount of HI indicated that a lesser dose exceeded the prescription dose. Therefore, according to the data in Appendix 1 (Table 1, 2), the patient with the minimum HI had better dose uniformity than other patients, a more homogeneous dose distribution in PTV for patients that treated with complete beam compared with half beam (The lower the HI, the optimal the dose homogeneity).
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 [20].
– 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) [18].
Data obtained from Table 2; indicated that the conformity index (CI) for five patients was >1. This indicated that the normal tissue received a high dose. However, for the other patients where CI < 1 this signified that the PTV was under coverage.
This indicated that the normal tissue received a high dose. However, for the other patients where CI < 1 this signified that the PTV was under coverage.
The results in Table 1 showed that CI was slightly improved with complete beam than half beam (0.926 vs. 0.889 cGy, $p<0.216$). Therefore CI with complete beam technique close of 1 (CI ≈ 1), that mean the prescribed dose conforms to the PTV shape with complete beam. Lungs are one of the first organs to receive radiation beam and to be protected during breast radiation [18].
However, in both techniques (complete beam, and half beam) statistically significant on Right lung (Rt-lung) via reduction of V5 in <5 Gy. There was a decrease in V20, V30, and D- mean values, although complete beam higher than half beam was (88.2±119.6, 29.4±20.5 cGy, $p<0.001$), but still they did not reach statistical significance. In both techniques satisfied the objective for V5Gy, V20Gy and V30Gy for Left lung (Lt- lung). The lowest V20Gy were found in complete beam while the highest with half beam(20.1, 20.8, $P<0.465$). Lowest D_{mean} was achieved in half beam while the highest value was observed in complete beam (1019.3, 1081.8 cGy, $p<0.003$).
In general, Our results show that both V5 Gy, V20Gy, V30Gy, D-mean values, and D_{max} were significantly higher in Left lung (Lt-lung) than Right lung(Rt-lung) by both techniques, as a results of location of Left lung which close of target area.
For heart, the objective V35<20GY or (2000 cGy) was achieved in both techniques. Its lowest value was found in half beam and highiest in complete beam (4.4, 2.2 Gy) <20 Gy. Our results showed that the mean dose to the heart higher with complete beam than half beam was (476.7, 373.8 cGy) <2600 cGy "Heart Tolerance mean dose (cGy)". Results from our study correspond with Gagliardi [21] who notes a considerable reduction of coronary heart disease at minimal dose of Gy.
Clinical effects of radiation induced heart disease have been detected at doses of >35 Gy to partial cardiac volumes. These risks are exacerbated during left breast radiotherapy. Other reported factors which significantly increase heart disease include age, sex, smoking, diabetes, obesity, hypercholesterolemia and hypertension [21].

V. 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. Although no safe dose limits can be given, the risk may be minimized. In principle, the irradiated volume should be as minimal as possible. The 3DCRT with two techniques achieved a significant reduction in the volume of heart and ipsilateral lung exposed to high-dose (≥40.05 Gy). In general, and these techniques might benefit patients with heart diseases, 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 the current research, for both techniques (complete beam, and 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 receiving even a lower dose (5 Gy) was increased. In a radiotherapy center like Zhianawa Cancer Center (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. Dose prescription and delineation process were performed by radiation oncologists at ZCC.

The RTP outcome that uses IMRT plans for breast cancer may provide a guideline for selecting a possible treatment technique for breast cancer at Zhianawa Cancer Center (ZCC) –Sulaimany-KR-Iraq.

Recommendation:

– We recommended using other 3DCRT techniques in Zhianawa Center that they reduce the risk of induce second cancers

– Our results conclude that the use of one isocentric in complete beam, and half beam with wedge technique is considerably advantageous in relation to ordinary tissue doses, less complex set up, minimizing of treatment time and PTV exposure.

– Methods that conduct single isocenter with complete and half beams are recommended as they provide improved dosimetric results and easier patient set up.

– The use of a single isocenter with both methods is not appropriate in each patient. In such cases isocentric half beam techniques should be recommended.

REFERENCES

[1]. Panayiotakis G. (2009). Measurements of peripheral doses in five clinical radiotherapy case with MOSFET detectors in anthropomorphic phantom –university of Patras.

[2]. Schubert, L. K., Gondi, V., Sengbusch, E., Westerly, D.C., Soisson, E. T., Paliwal, B. R., Mackie, T. R., Mehta, M. P., Patel, R. R., Tome, W. A., & Cannon, G. M. (2011). Dosimetric comparison of left-sided left breast irradiation with 3DCRT, forward-planned IMRT, inverse-planned IMRT, *helical tomotherapy and topotherapy. Radiother Oncol*, *100*, 241-246.

[3]. Mollah, A. S., & Sharmin, M. N. (2014). Dosimetric Comparison of Different 3DCRT Techniques in Left Breast Cancer Radiotherapy Planning. *Bangladesh Journal of Nuclear Medicine*, *17*(2), 108-113.

[4]. Ohashi, T., Takeda, A., Shigematsu, N., Fukada, J., Sanuki, N., Amemiya, A., & Kubo, A. (2009). Dose distribution analysis of axillary lymph nodes for three-dimensional conformal radiotherapy with a field-in-field technique for breast cancer. *International Journal of Radiation Oncology* Biology* Physics*, *73*(1), 80-87.

[5]. Kagkiouzis, J., Platoni, K., Kantzou, I., Dilvoi, M., Patatoukas, G., Kypraiou, E., & Kouloulias, V. (2017). Review of the three-field techniques in breast cancer radiotherapy. *J BUON*, *22*, 599-605.

[6]. Fournier-Bidoz, N., Kirova, Y., Campana, F., El Barouky, J., Zefkili, S., Dendale, R., & Fourquet, A. (2009). Technique alternatives for breast radiation oncology: conventional radiation therapy to tomotherapy. *Journal of Medical Physics/Association of Medical Physicists of India*, *34*(3), 149-152.

[7]. Akram, M., Iqbal, K., Isa, M., Afzal, M., & Buzdar, S. A. (2014). Optimum reckoning of contra lateral breast dose using physical wedge and enhanced dynamic wedge in radiotherapy treatment planning system. *International Journal of Radiation Research, 12*(4), 295-302.

[8]. Andic, F., Cifci, S. B., Ors, Y., Niang, U., Dirier, A., & Adli, M. (2009). A dosimetric comparison of different treatment plans of palliative spinal bone irradiation: analysis of dose coverage with respect to ICRU 50 Report. *Journal of Experimental & Clinical Cancer Research*, *28*(1), 1-7.

[9]. XiO®. Team EW. [Internet]. Elekta AB. [cited 2019 Sep 7]. Available from: \https://www.elekta.com/softwaresolutions/treatment-management/external-beam-planning/xio.html

[10]. MOSAIQ® Radiation Oncology [Internet]. [cited 2019 Sep 7]. Available from: https://www.elekta.com/softwaresolutions/care-management/mosaiq-radiation-oncology.html

[11]. Elekta Synergy, Linear Accelerator User Manuals.

[12]. Herrassi, M. Y., Bentayeb, F., & Malisan, M. R. (2013). Comparative study of four advanced 3d-conformal radiation therapy treatment planning techniques for head and neck cancer. *Journal of Medical Physics/Association of Medical Physicists of India*, *38*(2), 98-105

[13]. Khan, F. M., & Gerbi, B. J. (2012) Treatment planning in radiation oncology. Philadelphia, Wolters Kluwer/Lippincott Williams & Wilkins Health.

[14]. Pang, H., Lin, S., Yang, B., Wu, J., & Sun, X. (2019). A method for standardizing intensity modulated radiation therapy planning optimization for nasopharyngeal carcinoma. *International Journal of Radiation Research*, *17*(1), 177-181.

[15]. http://www.icru.org. Accessed May 9, 2016

[16]. Henson, K. E., McGale, P., Taylor, C., & Darby, S. C. (2013). Radiation-related mortality from heart disease and lung cancer more than 20 years after radiotherapy for breast cancer. *British journal of cancer*, *108*(1), 179-182.

[17]. Abo-Madyan, Y., Polednik, M., Rahn, A., Schneider, F., Dobler, B., Wenz, F., & Lohr, F. (2008). Improving dose homogeneity in large breasts by IMRT. *Strahlentherapie und Onkologie*. *Journal of Radiation, Oncology, Biology and Physics 184(2), 86-92.*

[18]. Petrova, D., Smickovska, S., & Lazarevska, E. (2017). Conformity index and homogeneity index of the postoperative whole breast radiotherapy. *Open access Macedonian journal of medical sciences*, *5*(6), 736-739.

[19]. Taylor, C. W., McGale, P., Povall, J. M., Thomas, E., Kumar, S., Dodwell, D., & Darby, S. C. (2009). Estimating cardiac exposure from breast cancer radiotherapy in clinical practice. *International Journal of Radiation Oncology Biology and Physics*, *73*(4), 1061-1068.

[20]. Roy, S., Mondal, D., Melgandi, W., Jana, M., Chowdhury, K. K., Das, S., & Rath, G. K. (2015). Impact of post-operative radiation on coronary arteries in patients of early breast cancer: A pilot dosimetric study from a tertiary cancer care center from India. *Indian journal of cancer*, *52*(1), 114-118.

[21]. Gagliardi, G., Constine, L. S., Moiseenko, V., Correa, C., Pierce, L. J., Allen, A.M., & Marks, L.B. (2010). Radiation dose-volume effects in the heart. *International Journal of Radiation, Oncology, Biology and Physics*, *76*(3), *Supplement*, S77–S85.

How to cite this article: Abdulkareem, Nashwan K. and Hassan, Fatiheea F. (2020). Comparative Study of Effectiveness of Peripheral Dose of Linear Accelerator Beam on Organs Near the Radiotherapy Field Edge in Complete, and Half Field Size X-ray Beam Techniques. *International Journal on Emerging Technologies*, *11*(1): 447–453.