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Dosimetric comparison study of intensity modulated radiotherapy technique (IMRT/VMAT) with three dimensional field-in-field tangents for left breast cancer irradiation

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Abstract---Purpose: To retrospectively compare dosimetrically three dimensional field-in-field tangents (3D F-in-F), Intensity modulated radiotherapy (IMRT) and volumetric modulated arc therapy (VMAT) left breast irradiation plans. Materials and Methods: A total of 30 patients were included in this study. All patients diagnosed with early –stage malignant neoplasm of the breast prior to treatment. Patients were contoured with three main PTV-Chest wall (PTV_{CW}), PTV-Axilla (PTV_{AX}), and PTV-IMC (PTV_{IMC}). Monaco treatment planning system was used to create the plans. For each patient, three treatment plans were created; three dimensional conformal radiotherapy (3D-CRT), intensity modulated radiotherapy (IMRT), and volumetric modulated arc therapy (VMAT). The dose coverage of PTVs and the dose constraints of Organ-at-Risks (OARs) were compared and analyzed. Results: The dose objective to cover the PTVs; PTV_{CW}, PTV_{AX}, and PTV_{IMC} were V40.43Gy (95%) ≥ 95%, V38.3Gy (90%) ≥ 95%, and V34.05Gy (80%) ≥ 95% respectively. Comparing the dose coverage of PTV_{CW} between 3D-CRT and VMAT, resulted in a significant difference (P= 0.003) and the

VMAT was superior for the coverage of target than 3D-CRT. For PTV_{AX} , the coverage was 45.80 ± 0.55 , 45.96 ± 0.73 , and 45.58 ± 0.63 for 3D-CRT, IMRT, and VMAT respectively. For PTV_{IMC} , the coverage was 45.80 ± 0.55 , 45.96 ± 0.73 , and 45.58 ± 0.63 for 3D-CRT, IMRT, and VMAT respectively. For OARs of breast cancer (heart and ipsilateral lung), the IMRT and VMAT were characterized by reducing the dose to these OARs than that at the 3D-CRT. While for contralateral organs, the 3D-CRT proved to be the best technique to deliver low dose to these organs. Conclusion: New radiation therapy techniques such as IMRT and VMAT improved the outcome of target coverage while reduced the radiation exposure risk of OARs for breast cancer. Although such new techniques do improve target coverage, homogeneity, and dose conformity to the target, they increase low doses to health tissue which may translate into an increased risk of secondary cancer.

Keywords---left-sided breast cancer, VMAT, IMRT, 3D-CRT.

Introduction

Radiotherapy is a cancer treatment that uses high-energy radiation beams directed to tumors to destroy cancer cells or shrink tumors.¹ Adjuvant radiotherapy (RT) for breast cancer is recommended as a standard treatment used to improve local tumor control or overall survival after breast conserving surgery or node positive mastectomy.² RT of patients with breast cancer is considered as a challenging to achieve the required dose coverage while keep the dose to Organ-at-Risks (OARs) within tolerance. Treatment planning is a challenge because with treating lymph node regions, the geometry of treatment volumes is more complicated than if the treatment for breast irradiation only. In this case, the planning for left-side breast is harder. Recently, the radiotherapy treatment of left breast cancer is improved much due to new treatment irradiation techniques.

Three-dimensional conformal radiotherapy (3D-CRT) still widely and routinely utilized for the treatment of breast cancer. In 3D-CRT, two-tangent radiation fields are defined with appropriate gantry angles to accommodate the target volume with utilizing special filters which placed in the beam path to improve the uniform dose distribution inside the target volumes. The wedge filter either physical or dynamic was the commonly used beam modifier to reduces the radiation intensity progressively across the beam and to compensate for the missing tissues. Because utilizing the wedges specially the physical, one of the disadvantages of the wedge was that the extra scatter of radiation which emanates from the wedge and integrated into the peripheral dose. For that reason, Field-in-Field (FiF)³ technique which also known as forward intensity-modulated radiotherapy (fIMRT) is introduced to replace the wedge. This new technology become available as a result of the introduction of multileaf collimators (MLCs) in radiotherapy machines. FiF technique is characterized by wedge technique besides eliminating the extra scatter of radiation which emanates from the wedge, it increases dose homogeneity in the target volume and improve dose distribution while decreases the absorbed dose in the irradiated

tissues outside the target.⁴

Inverse planning IMRT (iIMRT) is a modern treatment technique based on delivery of non-uniform fluence to the target volumes. In this technique, a homogenous dose distribution is achieved and controlled by applying dose constraints to the target volume and OARs. iIMRT is delivered currently using two main modes; 1) static mode (sliding window “dynamic” multileaf collimation “SW” or step-and-shoot “SS”) and 2) Arc or rotation mode (volumetric modulated arc therapy “VMAT”). In static modes either SS or SW, deliver dose from a discrete number of beam angles.⁵

With SW, the MLC slides across the treatment aperture at varied rates to paint a continuous fluence pattern. On the contrary, SS steps the MLC to a set of discrete aperture shapes and only delivers beam when the leaves are stationary at each position. This produces a fluence pattern with a number of discrete levels equal to the number of steps. The most modern and complex of these modes is VMAT which rotates the gantry of the treatment machine (linear accelerator “Linac”) around the patient for a partial or full arcs at a variable rate. The mechanism of VMAT is that the MLC are in constant motion with the radiation beam on during the rotation while the dose rate is continuously varied to weight the beam based on the incident angle. This method generates a fluence across a full or partial ring not across a single beam aperture only. The main advantage of this mode is controlling the dose distributions on target volumes and reducing the normal tissue and OARs doses.

Radiotherapy treatment of left-sided breast cancers results in increased risks of cardiac diseases and ischemic heart events.⁶⁻¹⁰ The radiation doses delivered to the heart, left anterior descending artery (LAD), and lungs when patients are in a supine position remain significant. In 2005, Darby et al.⁶ reported that 1.00 Gy increasing to the mean dose of the heart results in a 7.4% increase in the risks of major coronary events. These results are based on data collected from follow-up of patients treated with older radiotherapy. Modern radiation techniques such as 3-D CRT, IMRT, and VMAT, are considered to decrease cardiac and pulmonary doses and providing excellent coverage to the target volume.^{8,11-13} The continuous development in radiotherapy techniques are used to reduce doses to normal tissues and OARs. Also, there is a development in the management of the internal motion because the inspiration. This new technology is called “Respiratory Gating” technique.¹⁴⁻¹⁷

Respiratory-gated radiotherapy offers a significant potential for improvement in the irradiation of tumor sites affected by respiratory motion such as breast, lung, and liver tumors.¹⁸⁻²² The increasing of conformality of irradiation fields leading to decreases in the complication rates of OARs. The two main methods out of five main strategies which used to reduce respiratory motion effects in left-sided breast irradiation are breath-hold techniques or respiratory gating techniques. Both of these techniques are called deep inspiration breath hold (DIBH) technique. This technique is applied by two different ways; voluntary DIBH (ν DIBH) and moderate (or device monitoring) DIBH.²⁰ Moderate DIBH can be achieved with active techniques, in which airflow of the patient is temporarily blocked by a valve, or passive techniques, in which the patient voluntarily breath-

holds. On the other hand, respiratory gating techniques use external devices to predict the phase of the breathing cycle while the patient breathes freely. Another approach is tumor-tracking technique, which is the real-time position management (RPM) system²¹ (Varian Medical Systems, Palo Alto, CA) or Elekta Active Breathing Coordinator (ABC) system. Because the limited technology in our radiotherapy utility, our patients are scanned with ν HIBH without tracing system. The patients were guided during the scanning and treatments by radiotherapists. The common OARs delineated with breast cancer radiotherapy are: heart, ipsilateral lung, contralateral lung, contralateral breast, left anterior descending coronary artery (LAD), spinal cord, thyroid, liver, humeral head and trachea.²²⁻²⁵ It is not necessary to contour all of these structures but the selection from these structure group depends on the irradiated region and the potential of exposure any of these structures to an extra dose over its dose tolerance. There are very vast varieties of dose tolerances (or dose constraints) of OARs. These varieties depend on several parameters such as; radiotherapy regimens (normal fractionation, hypo-fractionation, of hyper-fractionation), the treatment technique (3D-CRT or IMRT & VMAT), the facilities of the institute (free breathing, ν DIBH, or tracking DIBH), verification system (Mega-volt imaging “MV-imaging”, “KV-Imaging, or cone beam computed tomography “CBCT”). In the QUANTEC²⁶, for 3D-CRT, the dose constraints to heart are: mean dose to heart is < 26 , $V_{30\text{Gy}} < 46\%$, and for whole organ and Long-term cardiac mortality as endpoint, $V_{25\text{Gy}} < 10\%$. For Spinal cord, with partial organ and 3D-CRT technique, $D_{\text{max}} = 50 - 69$ Gy depends on the myelopathy rate from 0.2 to 50 %. For lung, with whole organ and 3D-CRT technique, $V_{20\text{Gy}} \leq 30\%$ and the mean dose from 7.0 to 27.0 Gy depends on symptomatic pneumonitis rates from 5 to 40%. The mean dose for liver is $< 30-32$ Gy. With new technology such as IMRT and VMAT, which provide more control on the dose delivered to OARs, such these constraints become not acceptable from many institutions. For example, in United Kingdom (UK), there is a radiotherapy regimen called fast-forward trail where the breast is treated with dose prescription 26 Gy in 5 fractions (one week). In this protocol, the dose for ipsilateral lung is: $V_{8\text{Gy}} \leq 15\%$. The volume of heart receiving 1.5 Gy and 7.0 Gy should be less than 30% and 5% respectively. The mean dose to the heart is < 2 Gy.²⁷ The most common radiotherapy regimen used for breast nowadays is to give dose prescription 40.05 Gy for 15 fractions or 42.56 Gy for 16 fractions. In this regimen, the common constraints are; ipsilateral lung $V_{17\text{Gy}} < 25 - 30\%$, for the heart $V_{17\text{Gy}} < 10\%$.²⁸ The aim of this study is to compare the dosimetric parameters of various OARs planned with three different treatment techniques for the same patient during left-sided breast radiation therapy and evaluate OARs dose constraints.

Materials and Methods

Patients

In this study, thirty patients, with left-sided breast cancer planned with postoperative RT including the internal mammary node (IMN), were selected between April 2021 and March 2022. During scanning, patients were instructed to take deep breath and hold the breathing while the scanning was running as ν DIBH. Before scanning all patients underwent training to hold same volume of air inside the lungs each time they took and hold breathing. Patients were

scanned using SOMATOM Definition AS Computed Tomography Simulator (CT-Sim), VA48A, Siemens Medical Solutions. Accordingly, the simulation breast protocol utilizes in our department, patients were scanned with 5 mm slice thickness.

Treatment Planning System

Monaco treatment planning system (TPS) (Elekta AB, Stockholm, Sweden, version 5.11.02) was used to generate the plans. The Monaco TPS combines Monte Carlo dose calculation accuracy with robust optimization tools to provide high-quality radiotherapy treatment plans for 3D CRT, IMRT, VMAT. Recent technology advances have allowed for fast calculation speeds, which allow clinicians and patients to benefit from the accuracy of the Monte Carlo algorithm while reducing overall planning time.

Targets and OAR delineation and dose prescription

After scanning the patient, the acquired images were imported to Monaco TPS. The contours of breast, internal mammary chain (IMC), and axilla nodes are delineated following the RTOG breast cancer atlas.^{18,19} The clinical target volumes (CTVs) for chest wall, IMC, and Axilla were created by the radiation oncologist. Planning target volumes (PTVs) were generated by adding a certain margin around the CTVs. PTVs (PTV_{CW} and PTV_{IMC}) were generated by adding a certain margin of each CTV. For PTV_{CW}, 1-cm margin was added to CTV-chest wall. The PTV_{IMC} was generated from CTV-IMC by adding 0.5 cm margin all around with removing the part of PTV_{IMC} extended inside the ipsilateral lung. The PTV_{CW} was adjusted according to the lung surface and was 3-5 mm inside the skin. Radiation of 42.56 Gy in 16 fractions was prescribed to the PTVs. For CTV-axilla, the radiation oncologists contain the spread region implicitly. Therefore, the CTV for the axilla is considered the PTV of axilla. Table 1 shows the target volumes coverage and OARs dose constraints we are following in our institute. In our institute, the common OARs usually are delineated with breast cancer are heart, ipsilateral lung, contra-lateral breast, contralateral breast and spinal cord.

Treatment Planning techniques

In this study, each patient was planned for three times with three different treatment techniques; 3D-CRT, IMRT, and VMAT. 3D-CRT technique consists of two opposing fields called two tangential field techniques. Where, the dose is optimized using FiF technology to improve its homogeneity and reduce the hot dose areas. The gantry angle of medial tangent field is selected to accommodate the whole PTV while maintaining the ipsilateral lung and heart outside the treatment field as much as possible.

Table 1: The optimal objectives of planning target volumes (PTVs) and dose constraints of Organ-at-Risks (OARs)

Structure	Constraints
PTV_BREAST/CW	$D_{\max} \leq 110 \%$
	$V_{40.43\text{Gy}}(95\%) \geq 95\%$

PTV _{AX}	$V_{44.69\text{Gy}} (105\%) \leq 5\%$
	$D_{\text{max}} \leq 110\%$
	$V_{38.3\text{Gy}} (90\%) \geq 95\%$
	$V_{44.69\text{Gy}} (105\%) \leq 5\%$
PTV _{IMC}	$D_{\text{max}} \leq 110\%$
	$V_{34.05\text{Gy}} (80\%) \geq 95\%$
	$V_{44.69\text{Gy}} (105\%) \leq 5\%$
Heart	$V_{25\text{Gy}} < 10\%$
	Mean dose < 4 - 6 Gy
Ipsilateral Lung	$V_{20\text{Gy}} \leq 30\%$
Contralateral Lung	$V_{5\text{Gy}} \leq 5\%$
Contralateral Breast	$V_{5\text{Gy}} \leq 15\%$
	Mean dose < 4 Gy
Spinal cord	$D_{\text{max}} < 45 - 50\text{ Gy}$

The gantry angle of lateral tangent field is selected to match the two inner borders of the two beams to be straight to avoid unnecessary dose to the ipsilateral lung and heart. In IMRT technique, five static fields are created with gantry angles; 300°, 330°, 0°, 45°, and 125°. In IMRT technology, while the gantry angle is stationary for each beam, variable radiation intensity is generated across each beam by MLC. Each beam is subdivided into several beamlets, each with an individual intensity level which enabling a very complex pattern to be constructed. The use of several beams (five in this study) can build-up a highly conformal dose distribution at the same time sparing of the normal tissues. For VMAT, two partial arcs are used. The arc starts from 315° to 165° counter clockwise and back from 165° to 315° clockwise.

Results

Tables 2-4 show dose coverage of PTVs and dose constraints of OARs for thirty plans of each technique.

PTVs dosimetry

For the maximum dose (D_{max}) of PTV_{CW}, there was a non-significant difference ($p > 0.05$) amongst the three radiotherapy techniques. The average values of D_{max} for the three techniques 3D-CRT, IMRT, and VMAT were 46.64±0.36, 46.83±0.45, and 46.83±0.44 respectively. As a percentage, for 3D-CRT; the average 109.59%, maximum 111.61% and minimum 107.19%. For IMRT; the average 110.04%, maximum 112.10% and minimum 107.0%. For VMAT; the average 110.03%, maximum 112.34% and minimum 107.66%. These results showed that there is non-significant difference between the techniques. For the D_{max} of PTV_{AX} and PTV_{IMC}, p-values were 0.35 and 0.32 amongst the three radiotherapy techniques. This means that the difference was non-significance ($p > 0.05$).

The average dose coverage of PTV_{CW} with 3D-CRT, IMRT, and VMAT were 95.60±1.4, 97.28±1.4, and 97.40±1.5 respectively. Comparing the coverage doses of PTV_{CW} between 3D-CRT and VMAT led to a significant difference ($P= 0.003$) and the VMAT was superior for the coverage of the target. For PTV_{AX}, the coverage

dose values of 3D-CRT, IMRT, and VMAT were 45.80 ± 0.55 , 45.96 ± 0.73 , and 45.58 ± 0.63 respectively. For PTV_{IMC} , the coverage dose values of 3D-CRT, IMRT, and VMAT were 45.80 ± 0.55 , 45.96 ± 0.73 , and 45.58 ± 0.63 for respectively.

Table 3 illustrates the Conformity Index (CI) and Heterogeneity Index (HI) of three PTVs; PTV_{CW} , PTV_{AX} , and PTV_{IMC} , planned with three radiotherapy techniques. For HI, the difference between 3D-CRT and VMAT was significance ($P<0.05$), between 3D-CRT and IMRT was also significance ($p<0.05$). While difference between IMRT and VMAT was non-significance ($P>0.05$). For PTV_{IMC} , the differences between (3D-CRT and VMAT) and (IMRT and VMAT) were significance ($P<0.05$), but that between 3D-CRT and IMRT was non-significance ($p>0.05$). For CI, the difference between IMRT and VMAT for three PTVs was significance ($P<0.05$). Figure 1 illustrates the DVH of the sum of PTVs; PTV_{CW} , PTV_{AX} , and PTV_{IMC} for three techniques; 3D-CRT, IMRT, and VMAT.

Table 2: Average of dose objectives of planning target volumes (PTVs) for thirty left-sided breast cancer patients who were planned with three different radiation therapy techniques; 3D-CRT , IMRT and VMAT

PTV	Constraints	Technique		
		3D-CRT	IMRT	VMAT
PTV_{CW}	$PTV_{Dmax}(Gy)$	46.64 ± 0.36	46.83 ± 0.45	46.83 ± 0.44
	$V_{46.82Gy}(110\%) \leq 0\%$	0.00	0.00	0.00
	$V_{40.43Gy}(95\%) \geq 95\%$	95.60 ± 1.14	97.28 ± 1.4	97.40 ± 1.5
	$V_{44.69Gy}(105\%) \leq 5\%$	2.96 ± 1.8	2.85 ± 1.8	2.09 ± 1.6
PTV_{AX}	$PTV_{Dmax}(Gy)$	45.80 ± 0.55	45.96 ± 0.73	45.58 ± 0.63
	$V_{46.82Gy}(110\%) \leq 0\%$	0.00	0.00	0.00
	$V_{38.3Gy}(90\%) \geq 95\%$	98.76 ± 1.78	98.85 ± 1.48	99.45 ± 0.84
	$V_{44.69Gy}(105\%) \leq 5\%$	2.37 ± 1.63	1.95 ± 1.60	0.89 ± 1.25
PTV_{IMC}	$PTV_{Dmax}(Gy)$	45.01 ± 0.98	45.31 ± 0.89	45.80 ± 0.74
	$V_{46.82Gy}(110\%) \leq 0\%$	0.00	0.00	0.00
	$V_{34.05Gy}(80\%) \geq 95\%$	95.70 ± 5.66	97.77 ± 3.39	99.40 ± 1.32
	$V_{44.69Gy}(105\%) \leq 5\%$	1.78 ± 1.84	1.27 ± 1.58	1.16 ± 1.44

OARs dosimetry

Figure 3 is the DVH of different OARs such as ipsilateral lung (left lung), Heart, Spinal cord, contralateral breast (RT Breast) and contralateral lung (RT Lung). Results of thirty left-sided breast cancer patients planned with the three different techniques is illustrated in table 4. From this table and for the main OARs of breast cancer (heart and ipsilateral lung), the IMRT and VMAT are characterized by reducing the dose to these OARs more than that with the 3D-CRT. For example for the heart, the volume received 25 Gy of the heart is 4.05 ± 2.19 , 3.26 ± 1.32 , 2.42 ± 1.57 for 3D-CRT, IMRT, and VMAT respectively. On the contrary, the 3D-CRT is superior to IMAR and VMAT for some dose constraints. For example, the mean dose to the heart is 3.94 ± 1.10 , 6.52 ± 1.67 , and 6.83 ± 1.66 for 3D-CRT, IMRT, and VMAT respectively.

For contralateral organs (lung and breast), the 3D-CRT is the best technique to deliver low dose to these organs (figure 2). For example, the average of the volume received 5Gy of contralateral lung is 0.13 ± 0.18 for 3D-CRT, 5.50 ± 7.56 for IMRT, and 29.08 ± 14.57 respectively.

Table 3: Averages of Conformity index (CI) and Heterogeneity Index (HI) of planning target volumes (PTVs) for thirty left-sided breast cancer patients who were planned with three different radiation therapy techniques

		PTV _{CW}			PTV _{AX}			PTV _{IMC}		
		3D-CRT	IMRT	VMAT	3D-CRT	IMRT	VMAT	3D-CRT	IMRT	VMAT
CI	MAX	—	0.89	0.89	—	0.89	0.89	—	0.880	0.890
	MIN	—	0.60	0.61	—	0.62	0.64	—	0.610	0.620
	AV	—	0.73 ± 0.07	0.78 ± 0.06	—	0.74 ± 0.07	0.78 ± 0.06	—	0.73 ± 0.07	0.78 ± 0.07
HI	MAX	1.19	1.12	1.12	1.02	1.19	1.14	1.50	1.33	1.31
	MIN	1.02	1.02	1.03	1.14	1.02	0.11	1.03	1.01	1.01
	AV	1.12 ± 0.03	1.09 ± 0.02	1.08 ± 0.02	1.90 ± 0.15	1.07 ± 0.04	1.04 ± 0.18	1.19 ± 0.11	1.16 ± 0.09	1.10 ± 0.07

*CI: Conformity Index; HI: Homogeneity Index; MAX: Maximum; MIN: Minimum; AV: Average.

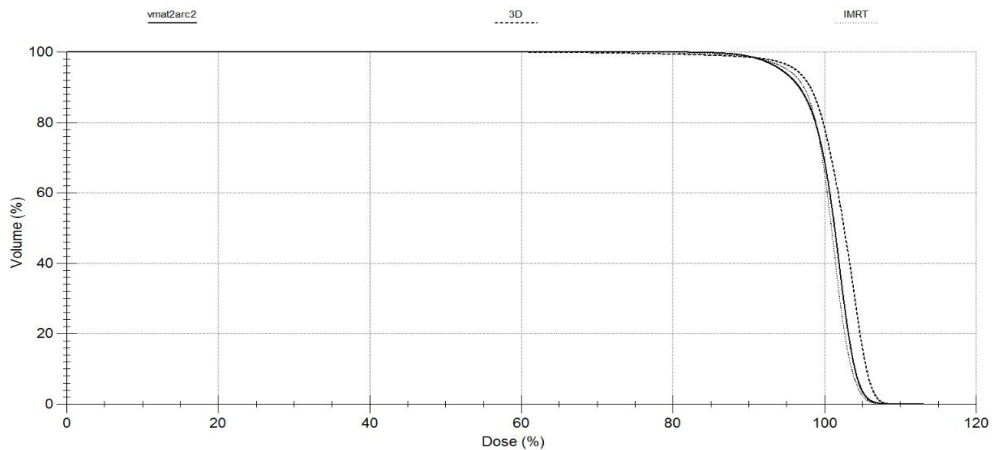


Figure 1: The dose-volume histogram (DVH) for Planning Target volume (PTV) for left-side breast cancer planned with three different techniques; (----) Three-Dimensional Conformal Radiation Therapy (3D-CRT), (·····) Intensity Modulated Radiation Therapy (IMRT), and (—) Volumetric Arc Radiation therapy (VMAT).

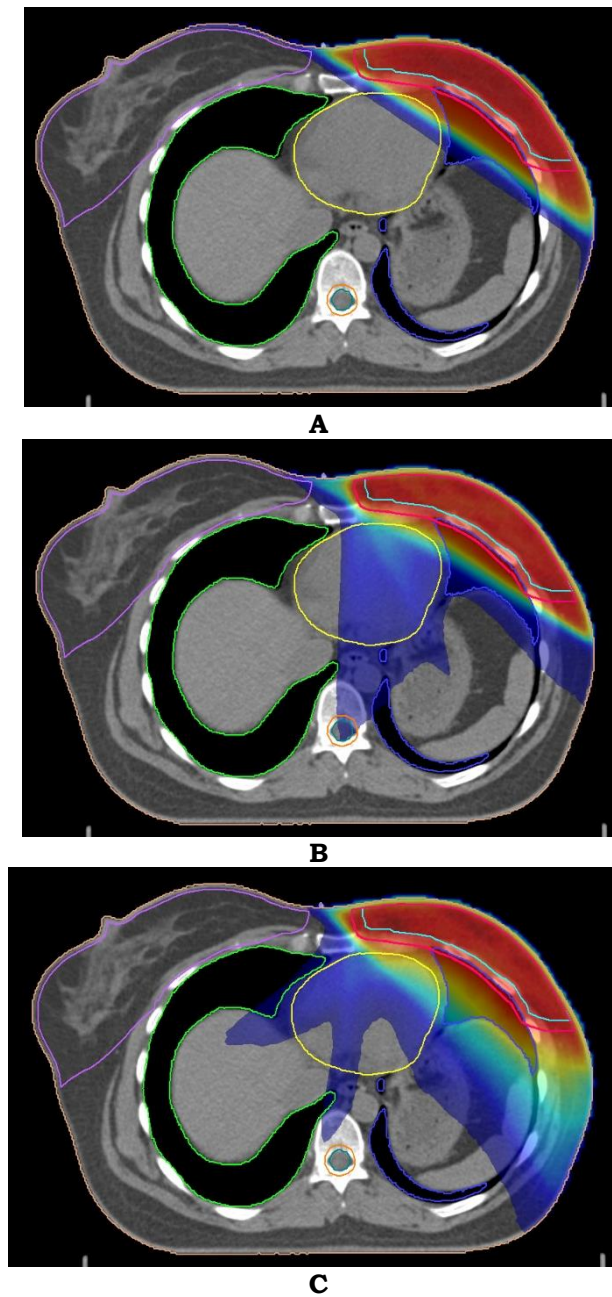


Figure 2: 10% dose level of prescribed dose for left-side breast cancer. A. 3D-CRT technique; B. IMRT technique; and C. VMAT technique.

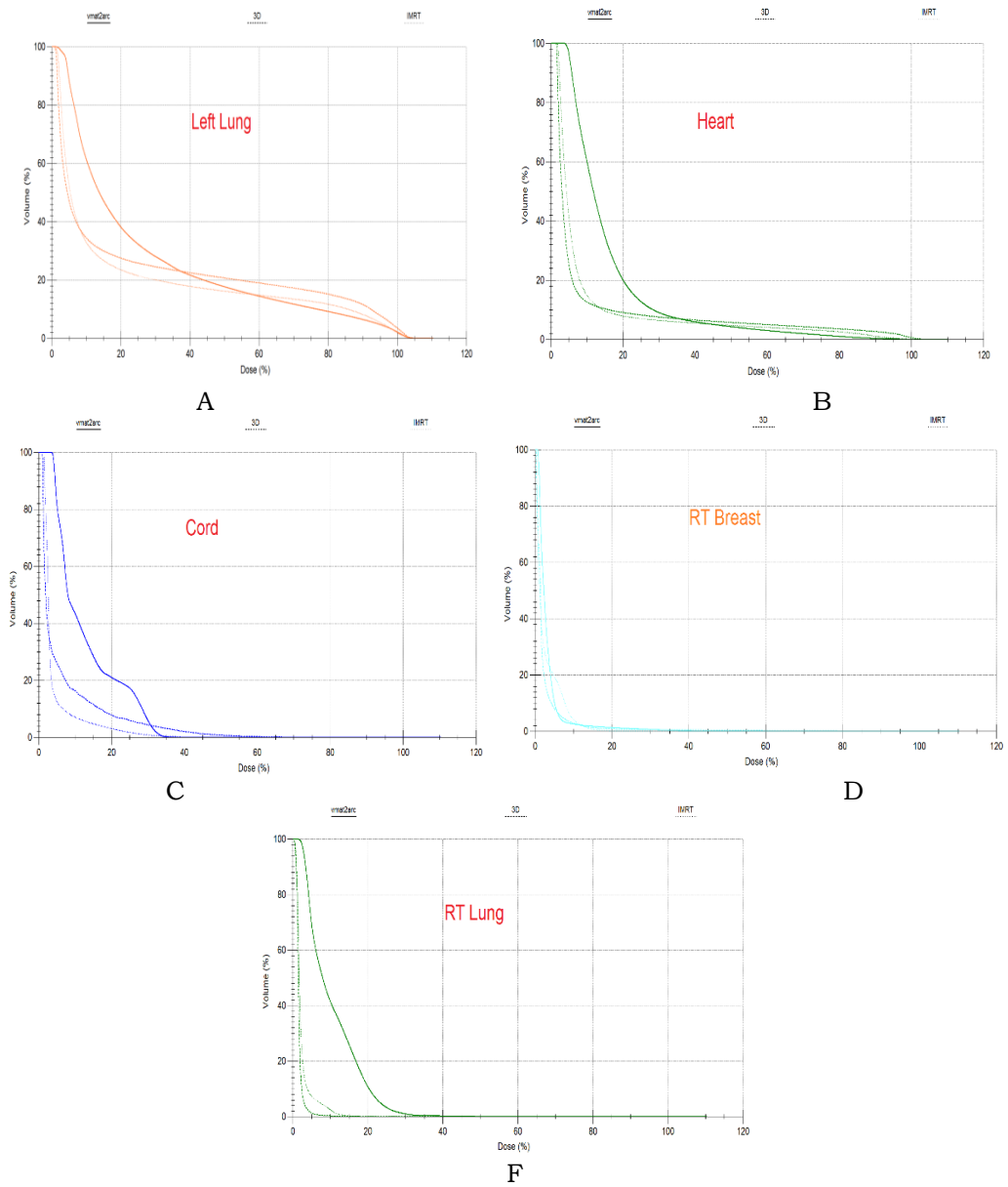


Figure 3: Dose-volume histogram (DVH) for organ at risks (OARs) for left-side breast cancer planned with three different techniques ; (----) Three-Dimensional Conformal Radiation Therapy (3D-CRT), (.....) Intensity Modulated Radiation Therapy (IMRT), and (—) Volumetric Arc Radiation therapy (VMAT).

Table 4: Average of dose constraints of Organ-at-Risks (OARs) for thirty left-sided breast cancer patients who were planned with three different radiation therapy techniques

OAR	Constraints	3D-CRT	IMRT	VMAT
Heart	$V_{25\text{Gy}} < 10\%$	4.05±2.19	3.26±1.32	2.42±1.57
	Mean dose < 4 - 6 Gy	3.94±1.10	6.52±1.67	6.83±1.66
Ipsilateral Lung	$V_{20\text{Gy}} \leq 30\%$	25.73±2.4 9	19.40±2.31	21.35±2.0 3
Contralateral Lung	$V_{5\text{Gy}} \leq 15\%$	0.13±0.18	5.50±7.56	29.08±14. 57
Contralateral Breast	$V_{5\text{Gy}} \leq 15\%$	1.71±1.19	2.21±1.43	1.71±0.7
	Mean dose < 4 Gy	1.11±0.25	1.31±0.27	1.36±0.19
Spinal cord	$D_{\text{max}} < 45 - 50 \text{ Gy}$	19.10±5.1 9	13.96±4.98	18.94±21. 83

Discussion

RT treatment planning for breast cancer has a long history. More than 50 years ago RT treatment planning for breast cancer was based on the tangential field technique. With the innovation of the millennium “CT-based conformal photon RT”, using a similar tangential field set-up had become the standard technique for RT breast cancer. In this technique, two opposed treatment fields angled to include as much of the breast PTV as possible and at the same time minimizing the amount of lung and heart inside the field was implemented. The field borders inside the body are aligned where the two borders for the two opposite beam are coincident to create a sharp penumbra of the beam and a strong dose fall-off gradient.

Creating a good treatment plan was made based on a set of dosimetric objectives for target volumes and constraints for OARs. A common dosimetric objectives for target coverage was at least 95% of the breast target volume in order to cover at least 95% of the prescribed dose. These dosimetric objectives were based on experience clinical practice and trials.^{21,29,30} For nodal targets, the required coverage dose was usually at 85–90% of prescribed dose which should cover at least 95% of the target volume. High dose volumes usually kept below 105–107% of prescribed dose with allowing up to 110% but only in very small volumes. At this level of high dose volumes, radiation induced late effects in the breast can which be kept at low acceptable rate.^{30, 32, 33}

OAR dose constraints were established from different sources. There were differences in the constraints of OARs in publications. In breast cancer, the main concerns regarding doses to OARs were doses to the heart³⁴, the lung and the contralateral breast.²⁹ New era of treatment planning is designed on CT-based, multi-field (FiF or forward IMRT planning) was registered as the standard for tangential planning to achieve a homogeneous dose distribution. The number of fields needed was depending on the shape and size of the target. As the plan become more complicated, the number of fields increases to achieve the desired homogeneity and target coverage. Although the use of FiF technique was

considered as advantageous, the disadvantage of this technique was in the increase of planning and treatment time.²⁹

To reduce the planning time, some techniques such as a hybrid technique where about 80% of the prescribed dose was delivered with two tangential open fields and 20% of the prescribed dose was delivered with IMRT or VMAT to ensure homogeneity. Other techniques such as tangential VMAT or IMRT in which, the field angles were limited to the angles also used for 3D-CRT tangential plans. The breast target volume in RT can be, with high heterogeneity, depending on many factors such as the stage of the tumor, the nodal involvement, tumour biology, extent of surgery and risk factors. In post-mastectomy patients, the target is the chest-wall with nodal regions but still can be with high heterogeneity due to the eventual presence of prosthesis or tissue expander.²⁹ For this high heterogeneity a wide variety of RT techniques can be used. In general, different target volumes may benefit from different irradiation techniques.

IMRT and VMAT³⁵ can improve parameters such as: target coverage, homogeneity, and dose conformity to the target. The drawback of the IMRT and VMAT was the increase of low doses to contralateral organs (lung and breast). This increase of the low dose translates into an increased risk of secondary malignant.³⁶ Sparing of ipsilateral organs at risk (Left Lung and Heart) is improved comparing with previous techniques. Nowadays, VMAT is generally much simpler and faster to deliver the prescribed dose comparing with multiple fields IMRT and also using much less number of MUs as in the past.³⁵ The VMAT is often applied using partial arcs to minimize the exposure of contralateral organs (Right Lung and Right Breast).

Conclusion

New radiation therapy (RT) techniques such as intensity modulated radiation therapy (IMRT) and volumetric modulated arc therapy (VMAT) allowed to individualize the RT volumes in breast cancer as opposed to the volumes in three dimensional treatment radiation therapy (3D-CRT). Although new techniques in radiation therapy such as IMRT and VMAT are used to treat breast cancer which can improve target coverage, homogeneity, and dose conformity to the target, these new techniques increase low doses to contralateral organs (lung and breast) which may translate into an increased risk of secondary cancer.

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