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The Feasibility of Hybrid IMRT treatment planning for Left sided Chest wall irradiation: A Comparative Treatment Planning Study

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ABSTRACT

Introduction: Due to the limited target volume and irregular body surface, irradiating the chest wall (CW) and lymphatic nodes is more challenging. IMRT and VMAT (volumetric modulated arc therapy) are two treatment delivery techniques that help to improve dose coverage and homogeneity while reducing irradiation to the heart and ipsilateral (I/L) lung. The use of a hybrid treatment planning approach for the ca-breast will impact the treatment plan. The hybrid planning system must be reviewed and compared to alternative treatment options for ca-breast cancer.

Material and Methods: For 10 patients undergoing left-sided breast chest wall irradiation, the 3 distinct planning techniques (FiF [Field-in-field], IMRT, and Hybrid IMRT) were evaluated. A prescription dose of 40 Gy in 15 fractions was used for the planned target volume (PTV). To compare plans, dose-volume histograms (DVHs) were assessed for PTV and organs at risk.

Results: $D_{95\%}$ of PTV was 37.10 ± 0.48 Gy in FiF, but considerably raised to 39.32 ± 0.34 Gy and 38.39 ± 0.29 Gy in IMRT (p=0.01) and Hybrid IMRT (p=0.01).When compared to IMRT (0.981 ± 0.014) and Hybrid IMRT (0.970 ± 0.013) FiF plans have the lowest CI value of 0.931 ± 0.026. IMRT plans (0.087 ± 0.021) were found to be more homogeneous than other 2 planning techniques (0.111 ± 0.013 [FiF, p=0.016], 0.107 ± 0.021[hybrid IMRT, p=0.056]).

Conclusion: Hybrid IMRT treatment plans for the ca-breast are recommended because they provide superior and similar PTV dose coverage and OAR sparing compared to FiF and IMRT plans. Hybrid IMRT plans feature lower MU and BOT, as well as a smaller low dose volume in comparison to IMRT.

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Introduction

Breast cancer is one of the most common cancer and cause of death in women across all well developed countries. [1-2]. It is estimated that in India, 50% of newly diagnosed breast cancer patients have advanced breast cancer [3]. Delay and negligence in proper diagnosis is the root cause of advance breast disease in developing countries. Multimodal management is the standard of care for advanced breast cancer. The reason for combining different treatment modalities such as surgery, chemotherapy and radiotherapy was to reduce the overall treatment morbidity without compromising treatment outcomes. According to reports, radiotherapy after breast surgery decreased the risk of a local recurrence within five years by 15.7% and the mortality risk within fifteen years by 4.2%. Post-mastectomy radiotherapy for node-positive disease also decreased the risk of a local recurrence within five years by 19.3% and the mortality risk within twenty years by 6.3% [4]. In early 90s Carcinoma-Breast (Ca-Breast) patients were only treated with conventional (2-Dimensional) rather than conformal (3-Dimensional) radiation therapy. Conventional radiation, such as Two-Dimensional Radiation Therapy (2D-RT), consists of tangentially rectangular radiation beams directed to the tumour from different directions creating a rectangular-shaped field typically exposes healthy tissues to unnecessary radiation which limits ability of dose escalation to the tumour.3D-radiation therapy utilizes the information from Computed tomography (CT) images and are helpful to identify the target area. This CT images are then fed to computer based treatment planning workstation to make the 3D-Conformal radiation treatment plan(3D-

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CRT).In 3D-CRT radiation beams are conformed according to shape of the target which tends to helpful in minimizing the radiation doses to the healthy tissue. Chest wall (CW) and lymphatic node irradiation is found to be more problematic due to thin target volume and irregular body surface also it lies parallel along the lung interface [5].In addition to pulmonary toxicity, the heart in case of left sided Ca-breast are at the risk of more radiation dose. Darby et al. have reported that there is linear relationship between the mean dose to heart and the associated coronary disease [6].Additionally in 3D-CRT there are always be unsatisfactory target coverage ,low conformity and homogeneity under coverage at CW and supraclavicular nodes (SCL) and hotspot doses outside the treatment volume remain concern [7]. Additionally, using physical compensators increases the scattered dose to the contralateral breast substantially [8]. This increases the risk of radiation-induced contralateral breast cancer in the patient [9].

Advancement in treatment delivery technique techniques like intensity modulated radiation therapy (IMRT) and volumetric modulated arc therapy (VMAT) help to achieve better dose coverage and homogeneity and lesser dose to the heart and ipsilateral Lung. There are plenty of literature available on Comparing 3D-CRT vs. IMRT, the dose distribution and doses to Organ at Risk (OARs).All studies suggested that IMRT Provides potential clinical benefit in terms of better target coverage and lesser radiation dose to OARs. [10-12]. However advance treatment radiotherapy technique provides lesser damage to healthy tissues, they are also have some shortcoming. IMRT and VMAT treatment delivery exposes more healthy tissue with significant higher volume of low dose. The main concern of IMRT is increase in healthy soft tissue dose and higher Monitor Unit (MU) which might cause an increased risk of late secondary malignancy [13].Apart from this there are additional complications available in the treatment planning processes, Quality Assurance (QA) and daily treatment with IMRT. Implementation of IMRT in Ca-Breast in the clinic will put a greater workload in the Radiotherapy (RT) departments. As a result, it is expensive for the patient. Therefore, it is important to take resource constraints into account while choosing the best RT for a patient [14]. New treatment planning techniques are needed for Ca-Breast especially for chest wall irradiation so that there will be reduction of dose to OARs and less MU. Charles S. [15] have proposed the concept Of hybrid IMRT that combines conventional open fields with IMRT fields calculated by inverse treatment planning algorithm for whole breast RT. Majority of the published literature has been reported the superiority of the hybrid IMRT in case of whole breast [16-18]. There has been limited study available on CW irradiation with hybrid IMRT. Our aim of this study is to dosimetrically analysis of 3DCRT, IMRT and hybrid IMRT treatment technique in left sided Ca-Breast. Our comparison will be based on target coverage, doses to the OARs and monitor unit.

Materials and Methods

Patient's Selection

For our study we have randomly selected 10 female patients with left sided Ca-Breast from department patient database. Their primary diagnosis was left breast carcinoma with supraclavicular or axillary lymph nodes (SCL). All patients were planned for 40.5 Gy for 15 fraction with daily dose of 2.67 Gy and treated with FiF treatment technique.

***CT Imaging*:** All patients were immobilized in the supine position and scanned with 2.5mm slice thickness in Siemens CT Scanner over the neck and at the end of the twelfth rib. Immobilization was achieved with a Carbon fibre breast board, and each patient's left arm was raised above the head to exclude it from the treatment field. On the patient's skin, radiopaque markers were applied as fiducial marks to help with any coordinate transformation required as a result of 3D planning and subsequent plan execution.

Target and organ at risk delineation

The Digital Imaging and Communication in Medicine (DICOM) images were uploaded to the Eclipse Treatment planning system after CE was planned (version 13.6, Varian Medical Systems, USA). The contours produced included the ipsilateral lung, contralateral lung, contralateral breast, heart, spinal cord, and body. They also included the clinical tumour volume (CTV), planning target volume (PTV), and gross tumour volume (GTV). With the aid of surgical clips positioned during surgery, the entire lumpectomy cavity, also known as the GTV (gross tumour volume), can be located. The constant 1.5 cm margin that was stretched in all directions surrounding the GTV in three dimensions served as the CTV's defining feature. However, this volume was restricted to only lie 5 mm against the primary muscle and inside the exterior contour. The radio-opaque wire kept during the CT simulation was defined as the PTV volume and was kept as deep as the muscles of the anterior chest wall. Semi-automatic contouring techniques are used to create the shape of the lungs and other exterior surfaces. The Radiation Therapy Oncology Group (RTOG) methodology created the CTV, PTV, and Organs at Risk (OARs).

Planning System and Radiotherapy Machine

The linear accelerator (LINAC) used to deliver treatment planning was Varian Unique performance Beam equipped with Single 6 MV photon energy. It comes with the Millennium 120 Multi leaf Collimator (MLC) which have total 60 pairs of leaves with 40 leaf pairs in the centre and 10 pairs on either side. The width of central and outer pairs of MLC leaves at the isocenter is 5 mm and 10 mm respectively. MLC can attains the maximum speed of 2.5 cm/s. The treatment planning system used for the external beam planning was Eclipse and final dose calculation was performed by Analytic anisotropic algorithm (AAA). Photon optimizer (PO) was used for inverse optimization (version 13.7.14). To preserve the comparison between the treatment methods, 6MV photon beams were used to create all of the treatment plans.

Planning technique

Three different Treatment planning approaches namely (1) Field in Field (FiF), (2) Intensity Modulated Radiotherapy (IMRT), (3) Hybrid-IMRT were utilised in the treatment of the ca -breast patient.

Field in Field planning: The FiF treatment plan consists of two main tangent field along with small sub-field directed towards the PTV. The sub-fields have lesser weightage as compared to main fields. Isocenter was positioned at the Junction of CW and SCL. SCL was planned separately with single anterior field. The beam angle were individually optimized depending on patient anatomy from 310° to 130°. After calculating dose hot and cold spot were seen inside the PTV qualitatively .sub fields were then added accordingly to boost the cold spot and shield the hot spot in order to improve the plan quality.

IMRT Planning: IMRT plans were planned with 4 to 6 beam angle ranging from 305° to 130°. All IMRT plans were optimized with Photon optimizer (PO). CW and SCL both were optimized in the same plan. AAA algorithm was used for the final dose calculation with dose grid size of 2.5mm. The optimization objectives and priorities were interactive to attain better possible results.

Hybrid planning: Hybrid IMRT plans consist of combination of 2 3D-CRT and 2 IMRT beam .Hybrid IMRT plans were prepared in two steps. Step1 consists of 2 tangent open beam conforming the breast PTV. Dose were calculated for above tangent fields with 60% beam weightage. In next step two IMRT beam with same beam angle as the 3DCRT was optimized keeping the 3DCRT plan as base plan. Fluence was calculated. In step 2 the 3DCRT beam was copied to IMRT plan and final dose was calculated. Hybrid plan consist of 60/40 ratio of 3DCRT and IMRT plans. All plans were normalized to deliver mean dose equal to prescribed dose.0.5cm bolus were added in all three treatment planning to have adequate dose coverage near skin level.

The dose objectives used PTVs and OARs while creating the plans are described in Table 1.

Treatment Planning Evaluation tools

A comparative Dosimetric analysis of left sided ca-breast was performed for 10 patients previously treated with FiF treatment planning technique and corresponding retrospective IMRT and Hybrid IMRT plans have been created. Each plan was evaluated with respect to the isodose distribution and dose-volume histogram (DVH), which were calculated for all the delineated volumes in all above mentioned three distinct planning techniques.

For the qualitative and quantitative evaluation of the treatment plans, TPS has a wide range of instruments. The isodose lines distribution treatment plans' visual slice-by-slice analysis can be utilised as a qualitative evaluation. To understand where the hot and cold spots are in treatment plans, it is crucial to conduct a qualitative assessment. The maximum, minimum, mean dose and DVHs were all included in the quantitative evaluation.

To assess the dose to various structures in various schemes, DVH was created. In order to evaluate a plan, the PTV metrics D98%, D50%, and D2% were employed, where D98% and D2% values represent the dose received by 98% and 2% of the PTV volume, respectively. $D_{98\%}$ represents the minimum dose to 98% of PTV volume indicating the “minimum dose”, and $D_{2\%}$ represents the minimum dose to the 2% of the PTV volume representing the “maximum dose” in the PTV, $D_{50\%}$ is the dose received by 50% volume of Target. For OARs, the mean dose and maximum dose for the heart, contralateral lung, and ipsilateral lung were used for treatment plan evaluation. In addition to this, the parameter $V_{95\%}$ and $V_{107\%}$ were also recorded for PTV as a measure for target coverage and also measure for the size of higher dose regions respectively, where

$V_{95\%}$ = the volume receiving at least 95% of the prescription dose.

$V_{107\%}$ = the volume receiving at least 107% of the prescription dose**.**

Table 1. Dose constraints for planning target volume (PTV) and organs at risk (OARs) used for treatment plans

Organ	Volume	Dose (Gy)
PTV chest wall	$V_{95\%}$ ≥95%. Max point dose 110%	
C\L breast	Max point dose≤3.86 Gy , D5%≤1.86Gy	
Oesophagus	Max. dose	47Gy
Heart (For left breast)	V_{20Gy}	≤25%
	V_{10Gy}	≤30-35%
	Mean	≤5 Gy
I\L Lung	V_{20Gy}	≤25-30%
	V_{10Gy}	≤35-40%
	V_{5Gy}	≤50-55%
C\L Lung	V_{5Gy}	≤10%

DVH was used to analyse the PTV's mean dose, maximum dose, and minimum dose and accordingly Conformity Index and Homogeneity Index were calculated using $V_{95\%}$, Target Volume, $D_{2\%}$, $D_{98\%}$ and $D_{50\%}$.

The International Commission on Radiation Units and Measurements Report 62, published in 1993, contains the RTOG's initial proposal for the conformity index (ICRU). It is displayed as a relationship between the target volume (TV) and the volume of the reference dose (VRI).

Conformity Index RTOG =

$$\frac{(The\ volume\ of\ the\ reference\ dose)}{The\ target\ volume\ (TV)} \quad (1)$$

C.I = 1 (one) is the ideal value.

To measure the conformity index, ranges of conformity index values have been created by the RTOG recommendations. The treatment is deemed to comply with the treatment plan if the conformity index is between 1 and 2; between 2 and 2.5 or between 0.9 and 1 is regarded as a minor violation, and below 0.9 and above 2.5 is considered a major violation of the protocol. It can be viewed as acceptable nonetheless. Though CI=1 is the ideal, true value, even if it were to exist, it wouldn't necessarily indicate that a high level of conformity had been attained.

The Homogeneity Index (HI), as defined in the International Commission of Radiological Units (ICRU) Report 83 [19], is

$$\text{Homogeneity Index HI} = \frac{D2\%-D98\%}{D50\%} \quad (2)$$

Where, $D_{2\%}$, $D_{98\%}$ and $D_{50\%}$ is the dose received by 2%, 98% and 50% of PTV volume.

HI= 0 is the ideal value.

Statistical Analysis

The information was entered into Excel 2007 by Microsoft. The paired t-test is a very acceptable study method for qualitatively analysing the two procedures.

The Statistical Package for Social Sciences (SPSS) version 12.0 (SPSS Inc., Chicago, USA) software was used to perform the statistical analysis mentioned above for the qualitative rating of the two methodologies. The statistical difference between the dose-volume data for FiF, IMRT, and hybrid IMRT was assessed using the one-way ANOVA test. The data were shown as mean and standard deviation. Two-tailed p-values are published, and p-values of 0.05 or lower are regarded as significant or not (NS).

Results

Patient Characteristics

Table 2 summarizes the patient characteristics. Patient selected for the study were having mean age of 49.5 ± 12.69 years, mean age ranging between 31years to 59 years. Mean PTV volume of the patient with standard deviation was 311.4 ± 126.64 cc. Volume of Right lung and left lung was 963.14 ± 175.16 cc and 871.25 ± 171.57 cc respectively. Mean heart volume and C\L breast volume of the patients reported in this study were 481.49 ± 113.96 cc and 823.28 ± 376.11 cc.

PTV dose Comparison

Figure 1 shows the colour dose wash of 95% of prescribed dose in all three plan and corresponding DVH for the OARs and PTV. Table 3 summarizes the Dosimetric planning indices of the PTV. D_{max} (maximum Point Dose) of the PTV was found to be highest in Hybrid IMRT (43.18 ± 0.85 Gy) in comparison to 42.5 ± 0.56 Gy and 42.25 ± 0.7 Gy in FiF (p=0.270) and IMRT (p=0.018) respectively. IMRT plans was reported with lowest Minimum point dose (D_{min}.)

Table 2. Summary of Patients characteristics.

Patients	Tumor Staging	Age (Yrs.)	PTV Volume (cc)	I/L Lung Volume (cc)	C/L Lung Volume (cc)	Heart Volume (cc)	C\L Breast Volume (cc)
1.	III	70	294.4	925.7	854.2	649.6	506.7
2.	III	41	109.1	1152.8	1114.1	352.5	1500
3.	IVB	31	252.5	1104.8	1106.4	406.8	927.8
4.	IV	58	424.6	904.5	689	509.1	352.8
5.	IV	59	263.4	1309.3	1054.4	657.8	628.1
6.	IIIB	37	417.2	770.9	741.3	535.4	1021.1
7.	IIIC	47	213.2	770.9	654.5	358	308.7
8.	IVB	59	315.5	842.8	758.9	460.5	985.4
9.	IIIc	37	264.7	925.7	854.2	649.6	1161
10.	IIB	56	559.4	1152.8	1114.1	352.5	841.2
Average		49.5	311.4	963.14	871.25	481.49	823.28
S.D		12.69	126.64	175.16	171.57	113.96	376.11

I\L=Ipsilateral; C\L=Contralateral; Gy=Gray; Vxx Gy= Volume received by xx dose in Gy. Yrs: Years cc:cubic centimeters S.D: standard deviations

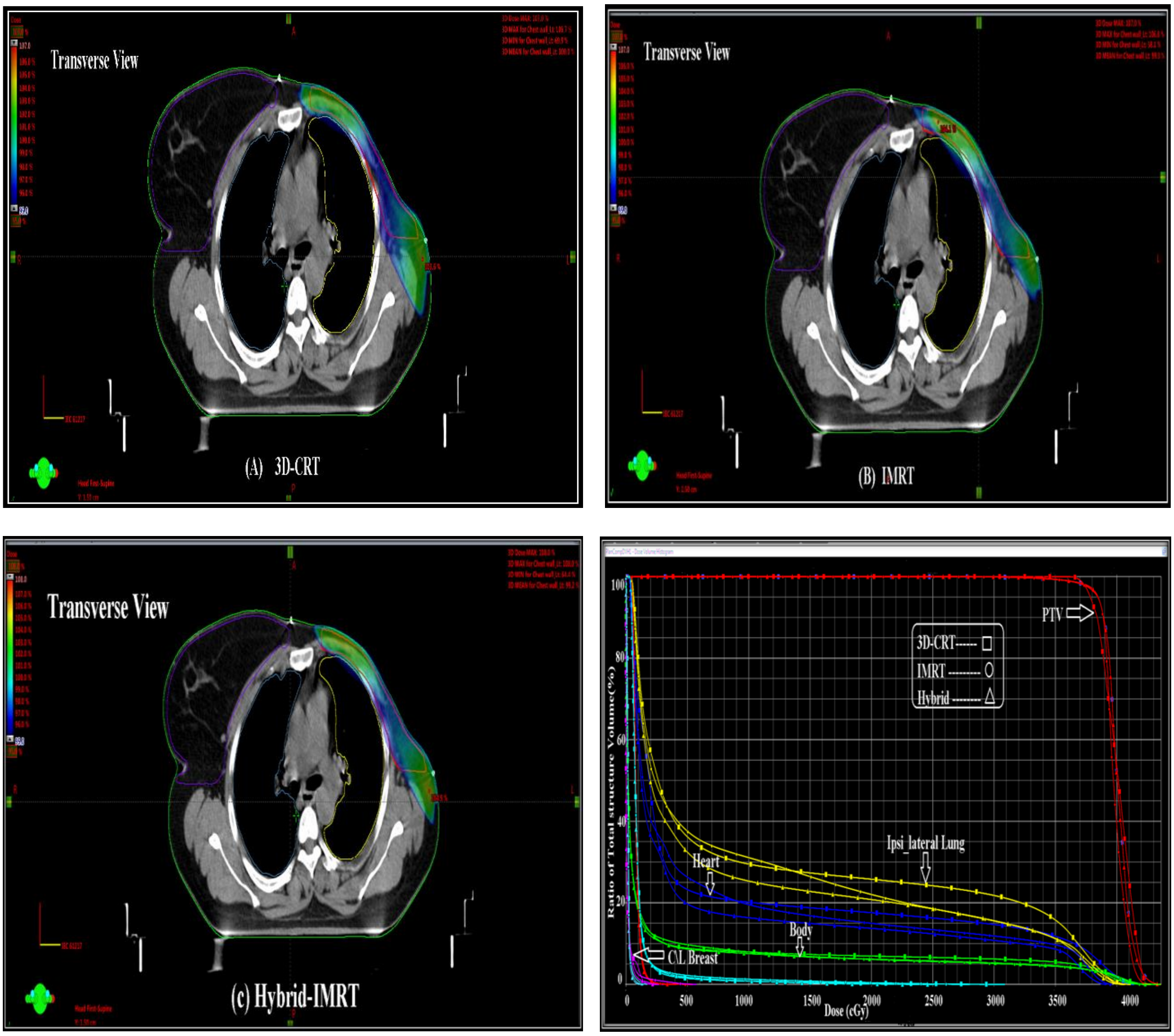

Figure 1. Shows the 95% of prescribed Dose in (A) 3D-CRT (B) IMRT and (C) Hybrid-IMRT and (D) DVH of PTV and OARs.

Table3. Summary of PTV dose Volume distribution.

Variables	FiF Mean±S.D	IMRT Mean±S.D	Hybrid IMRT Mean±S.D	p- Value		
				FiF Vs IMRT	FiF Vs Hybrid IMRT	IMRT Vs Hybrid IMRT
D_{max} (Gy)	42.5±0.56	42.25±0.7	43.18±0.85	0.270	0.380	0.018
D_{min}(Gy)	32.99±3.23	27.26±4.10	30.04±2.70	0.002	0.140	0.176
D_{mean}(Gy)	40.05±0.0	39.90±0.13	39.98±0.12	0.013	0.27	0.316
$D_{95\%}$ (Gy)	37.10±0.48	39.32±0.34	38.39±0.29	0.001	0.001	0.9
$V_{95\%}$ (cc)	291.50±122.29	305.30±123.24	302.39±121.72	0.89	0.90	0.9
CI	0.931±0.026	0.981±0.014	0.970±0.013	0.001	0.001	0.54
HI	0.111±0.013	0.087±0.021	0.107±0.021	0.016	0.56	0.056

D_{max}: maximum Point dose D_{min}. : Minimum Point dose D_{mean}: mean dose
$D_{xx\%}$: dose to XX % of Volume. $V_{yy\%}$: Volume covered by yy % of dose.
CI: conformity Index HI: Homogeneity index.

Inside the PTV with mean dose of 27.26 ± 4.10 Gy, which significantly increased to 32.99 ± 3.23 Gy in FiF plans (p=0.002). D_{min} for hybrid IMRT attained the mean dose of 30.04 ± 2.70 Gy. $D_{95\%}$ of PTV achieved the lowest value of 37.10 ± 0.48 Gy in FiF which significantly improved to 39.32 ± 0.34 Gy and 38.39 ± 0.29 Gy in IMRT (p=0.01) and Hybrid IMRT (p=0.01). FiF plans have lowest CI value of 0.931 ± 0.026 as compared to IMRT (0.981 ± 0.014) and Hybrid IMRT (0.970 ± 0.013). CI value in FiF significantly goes higher in IMRT (p=0.01) and Hybrid IMRT (p=0.001) but this increase was insignificant between IMRT and Hybrid IMRT. IMRT plans (0.087 ± 0.021) were found to be more homogeneous than other 2 planning techniques (0.111 ± 0.013 [FiF, p=0.016], 0.107 ± 0.021[hybrid IMRT, p=0.056]).

OARs dose comparison

Table 4 shows the summary of OARs doses, where we tabulated the doses for ipsilateral (I/L) lung, Right Lung, Heart and Contralateral (C/L) breast. I/L lung V_{5Gy} was highest in IMRT 36.75 ± 5.57 which significantly shows dose fall of 29.96 ± 5.16 Gy and 27.64 ± 5.53 Gy in FiF(p=0.025) and Hybrid IMRT(p=0.015).V_{10Gy} of I/L lung irradiated with 21.39 ± 4.27 Gy in Hybrid IMRT . V_{10Gy} insignificantly increases to 23.46 ± 4.99 Gy in FiF (p=0.39) and it significantly raises to 28.77 ± 7.09 Gy in IMRT (p=0.01) when compared with Hybrid IMRT. V_{20Gy} of I/L lung was 20.27±4.08 Gy in FiF, it falls insignificantly to 17.75±3.45 Gy and 17.20 ± 3.72 Gy in IMRT (p=0.31) and Hyrid IMRT (p=0.18) in comparison to FiF plan. Mean I/L lung dose was 11.47±0.54 Gy in FiF and it significantly reduces to 8.45 ± 1.52 Gy and 7.83 ± 1.51Gy in IMRT (p=0.01) and Hybrid IMRT (p=0.01) respectively.

V_{5Gy} of C/L lung was recorded a dose of 13.3±4.71 Gy, 9.7±2.00 Gy and 9.93±2.81Gy in IMRT, FiF and Hybrid IMRT respectively.$V_{20\%}$ of heart was insignificantly highest for FiF (10.05±3.29 Gy) in comparison to IMRT (8.31±3.29 Gy) and FiF (7.68±3.78 Gy). $V_{10\%}$ of heart was 14.22±2.22 Gy in IMRT and it significantly reduces to 10.55±3.23 Gy in Hybrid IMRT although this reduction of 11.94±2.31 Gy was insignificant for FiF. Mean heart dose was lowest for FiF (3.80±1.23 Gy) and significantly increases to 4.23±1.02 Gy and 5.28±0.89 Gy in IMRT and FiF respectively. D_{max} for C/L breast was highest for IMRT (9.19±4.86 Gy) and significantly cut down to 3.67±2.71 Gy and 4.69±3.53 Gy in FiF and Hybrid IMRT respectively. $D_{5\%}$ of C/L breast received 1.07±1.24 % in IMRT and this value comes down in significantly to 0.72±0.45 % and 0.82±0.58 % in FiF and Hybrid IMRT.

Table 5 shows the summary of Monitor Unit (MU) and Beam on Time (BOT).No. of MUs were higher for the IMRT 751.00 ± 125.52 and significantly declined to 322.90± 11.46 and 510.20±28.95 in FiF and Hybrid IMRT treatment planning's respectively. Beam on Time for IMRT was reported with Value of 1.25±0.21 min. which goes down to a value of 0.54±0.02 min. and 0.85±0.04 min. in FiF and Hybrid IMRT respectively.

Table 4. OARs dose distributions summary.

Variables	FIF Mean±S.D	IMRT Mean±S.D	Hybrid Mean±S.D	p- Value		
				FiF Vs IMRT	FiF Vs Hybrid	IMRT Vs Hybrid
LT.Lung V_{5Gy} (cc)	29.96±5.16	36.75±5.57	27.64±5.53	0.025	0.59	0.015
LT.Lung V_{10Gy} (cc)	23.46±4.99	28.77±7.09	21.39±4.27	0.39	0.67	0.01
LT.Lung V_{20Gy} (cc)	20.27±4.08	17.75±3.45	17.20±3.72	0.31	0.18	0.9
LT.Lung Mean(Gy)	11.47±0.54	8.45±1.52	7.83±1.51	0.001	0.001	0.52
RT.Lung V_{5Gy} (cc)	9.7±2.00	13.3±4.71	9.93±2.81	0.06	0.89	0.08
HeartV_{20Gy} (%)	10.05±3.29	8.31±3.29	7.68±3.78	0.51	0.29	0.90
HeartV_{10Gy} (%)	11.94±2.31	14.22±2.22	10.55±3.23	0.15	0.47	0.012
Heart Mean (Gy)	5.28±0.89	4.23±1.02	3.80±1.23	0.08	0.011	0.63
C\L breast Max. dose (Gy)	3.67±2.71	9.19±4.86	4.69±3.53	0.08	0.8	0.03
C\L breast $D_{5\%}$ (Gy)	0.72±0.45	1.07±1.24	0.82±0.58	0.61	0.89	0.60

VxxGy: Volume of xx Gy of dose in percentage

Table 5. Shows the summary of Monitor unit and Beam on Time

Variables	FiF Mean±S.D	IMRT Mean±S.D	Hybrid ean±S.D	p- Value		
				FiF Vs IMRT	FiF Vs Hybrid	IMRT Vs Hybrid
MU	322.90± 11.46	751.00±125.52	510.20±28.95	0.001	0.001	0.001
BOT (min.)	0.54±0.02	1.25±0.21	0.85±0.04	0.001	0.001	0.001

MU: Monitor Unit BOT: Beam On Time.

Discussion

Our study aims at assessing and comparing the dose distribution within the PTV and doses to OARs between FiF and advance technique like IMRT and Hybrid IMRT. Planning comparisons and dosimetric studies of different treatment technique like 3DCRT, IMRT or VMAT in breast cancer have been evaluated in a large number of studies, and there has always been a discussion on the use of the sophisticated techniques in radiation practice. SCF half-blocked fields and tangential half-blocked fields are commonly utilised. According to planning comparative studies, VMAT is recommended over IMRT and 3DCRT in post-mastectomy breast cases to achieve a lower dose of OARs and improved PTV coverage, CI, and HI [20–23]. Open tangential 3DCRT fields combined with IMRT or VMAT have been employed as the basic dosage plan in the majority of published studies [24–25]. Contrarily, Lin et al. H-VMAT.'s trial employed tangential IMRT (T-IMRT) as the first dose strategy [26]. Two tangential fields, such as 3DCRT, have been combined with IMRT in the T-IMRT scheme. The open 3DCRT approach and T-IMRT produce similar OAR doses, according to the Viren et al. study, although T-IMRT produces greater MUs [27]. As a result, IMRT was excluded from the current study as a base dose plan and a hybrid plan.

The fundamental goal of the hybrid technique is to preserve the Heart, I/L, C/L lung, and C/L breast to avoid radiation-induced secondary cancers and long-term consequences (such as heart failure and lung pneumonia). The maximum Point dose (D_{max}) inside the PTV was the lowest for the IMRT, with a jump of 0.6% in FiF and 2.2% in Hybrid IMRT. D_{min} was found to be highest in FiF and decreases to 8.94 % in hybrid IMRT and 17.8% in IMRT. Dose coverage with the prescribed dose has improved to 3.48% in Hybrid IMRT and 5.98% in IMRT compared to the FiF planning technique. Figure 2. Shows the CI distribution across the three different planning techniques. CI values have increased profoundly by 11% and 12.22% in Hybrid IMRT and IMRT respectively compared to FiF. IMRT and Hybrid IMRT plans were 21.22% and 3.6% more homogeneous than FiF plans. Figure 3. Shows the HI distribution across three different treatment planning strategies. These results shows that IMRT have better dose coverage and Uniformity for PTV among other 2 techniques. Hybrid IMRT plans also have a significant increase in CI and HI in comparison to FiF plans but are not much different from IMRT.

Although there is a risk of problems, radiation therapy improves treatment outcomes in women with breast cancer. The most dangerous late adverse effects are difficulties with the heart and lungs and second cancers that are breast or lung- or lung-specific. Cardiac issues develop over ten years after treatment. Over the ensuing ten years, they are to blame for a 30% increase in cardiovascular fatalities. These statistics deal with post-mastectomy radiotherapy and breast preservation [28, 29]. According to a number several, the incidence of major coronary accidents increases by 7.4% for every additional 1Gy added to the Standard Heart Dose [30–31]. Figure 4. Shows the average heart dose variation across the 3DCRT, IMRT and Hybrid-IMRT planning techniques. The D_{mean} of heart was lowest in Hybrid IMRT and it raises to 11.31% in IMRT and 35% in FiF. Mean heart dose for FiF was violating our dose constraints. $V_{20\%}$ and $V_{10\%}$ of heart are good predictors of heart risk and are very low in hybrid IMRT compared to FiF and IMRT. $V_{20\%}$ of heart was 30.55% (FiF) and 8.20% (IMRT) higher than Hybrid IMRT, which indicates the more volume of heart being irradiated in FiF plan.

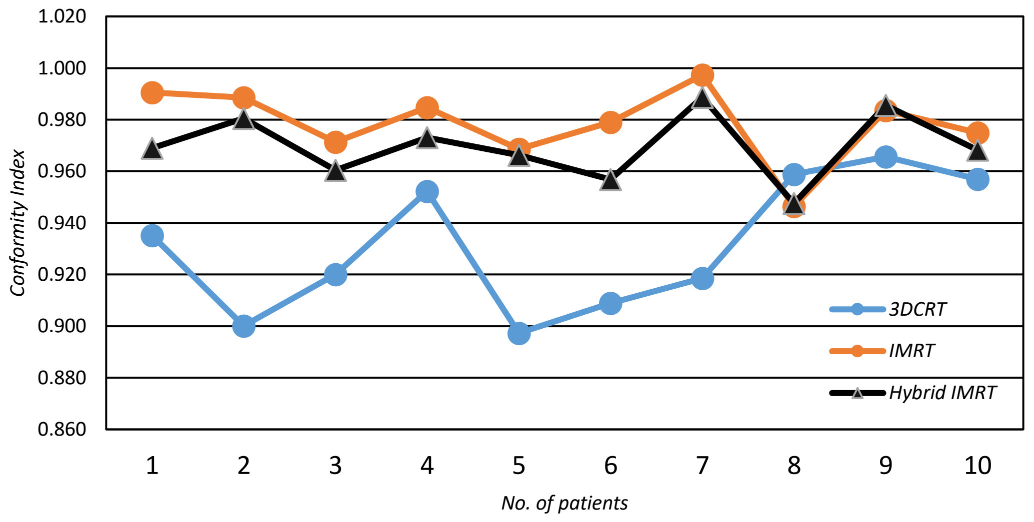

Figure 2. Variation of Conformity Index (CI) across the three different planning technique.

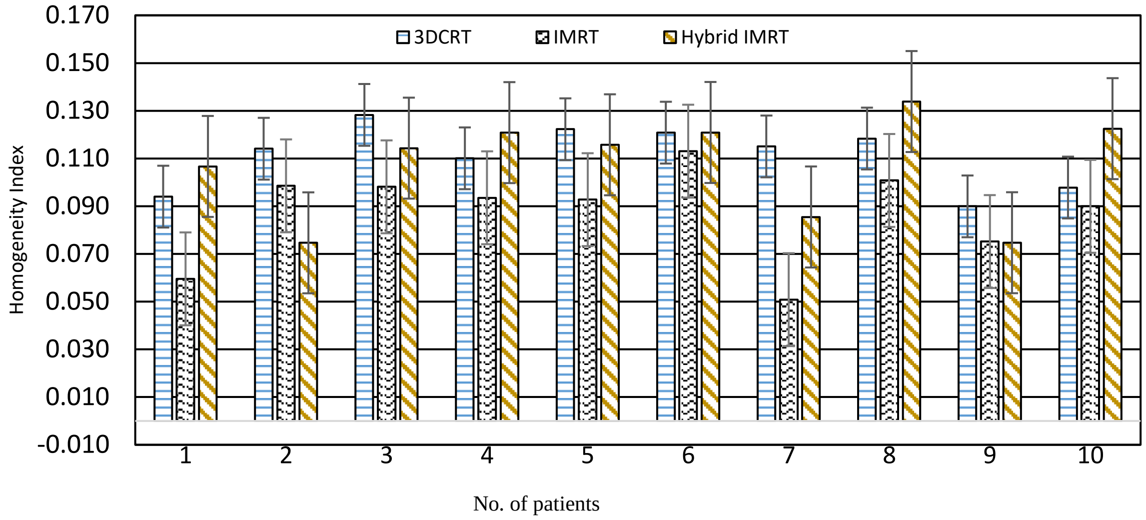

Figure 3. Shows the Homogeneity Index (HI) variation across the 3DCRT, IMRT and Hybrid IMRT treatment plan.

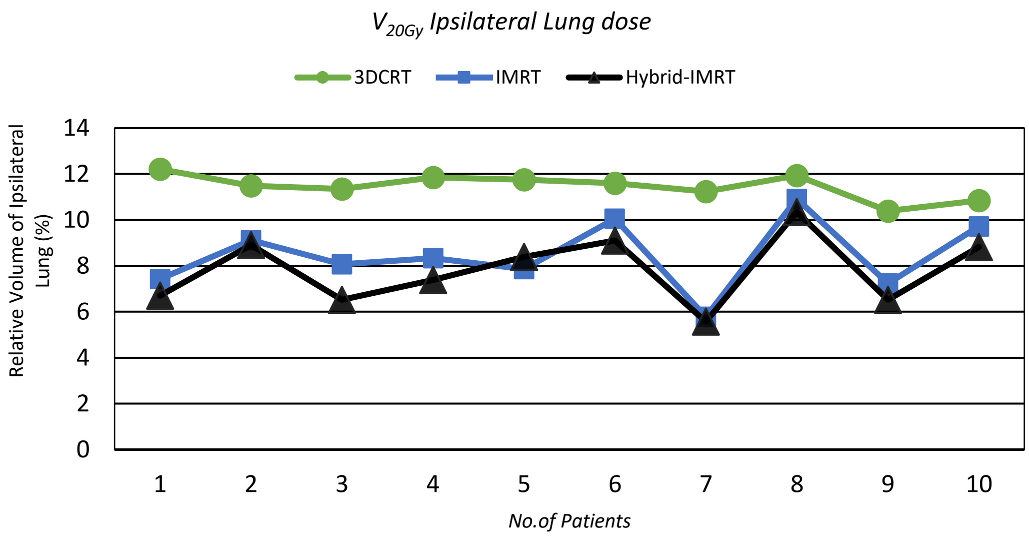

Figure 4. Distribution of V_{20Gy} I/L lung dose across the patients for different treatment technique.

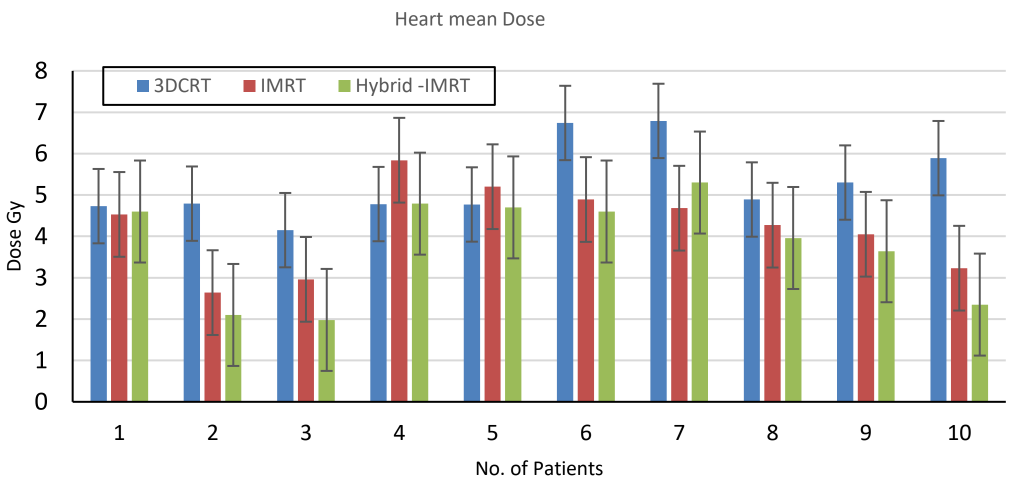

Figure 5. Mean Heart dose variation across the three different planning technique

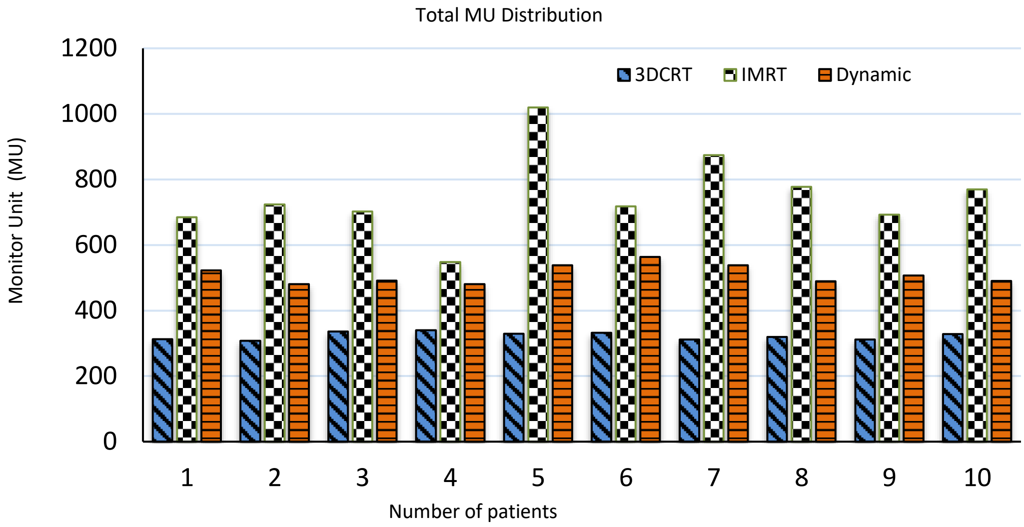

Figure 6. Monitor Unit (MU) variation among three different planning strategy.

Whereas $V_{10\%}$ of heart was recorded 34.78% and 13.17% increase in IMRT and FiF plan compared to Hybrid IMRT. This means that the low dose region exposing the healthy tissue of heart more in IMRT by irradiating more heart volume. The literature indicates the system used to perform Radiation therapy (planning technique, arrangement of beams, no of beams) can indirectly affects the development of heart complications. The most significant considerations are the distribution of the dose, the dose tolerance limit in vital organs and dose in fractions.

Pulmonary complications are the second major group of complications that may occur in patients treated with breast cancer. Immediately following radiotherapy, patients can experience radiation pneumonitis that will later develop into irradiated lung fibrosis. Respiratory insufficiency is the physiological result of this complication. Estimate of lung volume that received a dosage equal to or greater than 20Gy (V_{20Gy}) is a significant element in minimizing the probability of complications. If the V_{20Gy} of the ipsilateral lung was <30% for breast cancer patients, clinically significant pneumonitis should be rare. Figure 5. Show the V_{20Gy} I/L lung dose distribution in all the treatment plans.

In our study, V_{20Gy} was well below the limit across all the treatment planning strategies. V_{20Gy} for I/L lung was highest for the FiF plans and comparatively gets lowered by12.43% and 15.14 % in IMRT and Hybrid IMRT plans respectively. V_{10Gy} and V_{5Gy} were found to be more in IMRT plans when compared with other treatment plans. In IMRT, the amount delivering a reduced dosage is higher than in most radiotherapy strategies. Another crucial point to keep in mind is the dose to the contralateral breast, especially in younger patients. Stovall et al. [32] also reported an increased long-term risk of developing secondary contralateral breast cancer. In our study, the IMRT reported with highest max. Dose to contra lateral breast and this max. Dose gets reduced by 48.96% in Hybrid plan and by 60% in FiF plans.

Figure 6. Shows the MUs variation along the three planning strategies. More MUs and prolonged therapy lead to higher out-of-field leakage doses and scattered radiation to normal tissue and, which, in essence, are expected to increase the occurrence of radiation-induced malignancy. Hall et al assessed the prevalence of secondary neoplasm after 10 years and found that the rate of radiation-induced malignancy in 3D-CRT was 1% increased to 1.75 per cent of IMRT [33]. In our study IMRT plans were having more MUs, which successively cut down to 57.0% in FiF and to 32.7% in Hybrid IMRT plans. Beam on Time (BOT) is another parameter which is related with the treatment delivery time on the couch inside the treatment room during treatment delivery. BOT is the actual time for which beam was on excluding the gantry movement and patient setup time. Higher BOT indicates the more time on couch for in room patient leading to patient discomfort and matter of concern for patient treated with respiratory motion management. Kry et al. have shown that relative to 3D-CRT, IMRT proposals have improved MU and varying dosage distribution and that this variation would double the occurrence of secondary solid tumours [34]. In current study IMRT plans were recorded with higher BOT, which significantly gets pull down by 56.8% and 32% in FiF and Hybrid IMRT.

Conclusion

Several literature have concluded that the IMRT treatment plans are superior to FIF in terms of PTV coverage and OARs sparing. Here in our study, we also found that IMRT treatment plans have more target conformity and homogeneity compare to FiF and Hybrid IMRT. But IMRT treatment plans have some limitation regarding higher low dose volume of OARs, high MU and more BOT. We recommend that the Hybrid IMRT treatment plans to be adapted for the ca-breast as these treatment modality have superior and comparable PTV dose coverage and better OARs sparing than FiF and IMRT treatment plan. Hybrid IMRT plans characterised by the Lower MU and BOT and lesser lower dose region to OARs. Hence reducing the risk of secondary cancer. Also the Hybrid IMRT treatment plans are comparatively less time consuming than FiF and IMRT. So Hybrid plans are boon to the centre where there have too much patient load. Hybrid IMRT will provide the comfort to the patient by reducing their in room time during treatment. So finally we conclude on the basis of our study that Hybrid treatment plans potentially have given acceptable target coverage and OARs sparing and can be adapted in regular practice. Inclusion of Hybrid IMRT treatment planning technique into the clinical practice will reduce the planning burden of the planner and decrease the PSQA load.

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