Section: Radiation Oncology

Original Research Article

DOSIMETRIC COMPARISION OF CONVENTIONAL HALF BEAM BLOCK BY THREE-DIMENSIONAL CONFORMAL RADIOTHERAPY TECHNIQUE VERSUS HALF BEAM BLOCK SPLIT TANGENTIAL FIELD USING THREE-DIMENSIONAL CONFORMAL RADIOTHERAPY FOR LEFT-SIDED POST-MASTECTOMY RADIOTHERAPY

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Received : 21/03/2023
Received in revised form : 19/04/2023
Accepted : 01/05/2023

Keywords:
Half beam block, Split tangential field, Left sided post- mastectomy radiotherapy, Single isocentre, Dosimetric analysis, Planning Target Volume.

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DOI: 10.47009/jamp.2023.5.3.41

Source of Support: Nil,
Conflict of Interest: None declared

Int J Acad Med Pharm
2023; 5(3); 187-191

Abstract

Background: Radiotherapy techniques such as 3DCRT, IMRT and VMAT are used to reduce local recurrence and prevent long-term complications of PMRT. However, increased integral dose in normal healthy tissue is the primary concern. The study aims to compare the dosimetric parameters of different 3DCRT [Three-Dimensional Conformal Radiotherapy] techniques. **Materials and Methods:** Twenty patients with locally advanced left-sided breast carcinoma with involved or high risk for involvement of IMN [Internal mammary node] who underwent left MRM [Modified radical mastectomy] followed by adjuvant chemotherapy were retrospectively selected. Conventional 3DCRT [Three-Dimensional Conformal Radiotherapy] techniques [Field-in-field, 3DCRT(Three-Dimensional Conformal Radiotherapy Technique) with wedge] were compared with Split tangential field technique and dosimetric analysis were done. **Results:** We analyzed the dosimetric parameters, such as homogeneity index[HI], conformity index[CI], PTV[Planning Target Volume]-chest wall D95%, PTV-SCF[Planning Target Volume- Supraclavicular Fossa] D95%, maximum dose, mean dose as well as mean doses of OARs[Organs at risk] in three techniques. The split tangential field half-beam block technique shows better PTV[Planning Target Volume] coverage and a 10% reduction in OAR [Organs at Risk]constraints compared to the routine HBB[Half Beam Block] technique. **Conclusion:** Split tangential field half-beam block technique using a single isocentre can reduce OAR constraints and reduce long-term complications of PMRT.

INTRODUCTION

Post-mastectomy radiotherapy [PMRT] becomes integral in management of locally advanced breast carcinoma, reducing locoregional recurrence and improving survival rate. External Beam Radiation Therapy [EBRT] was considered the most common radiation therapy technique to treat breast carcinoma.[1-3]Various radiotherapy techniques such as 3DCRT[Three-Dimensional Conformal Radiotherapy Technique],IMRT[Intensity Modulated Radiotherapy],and VMAT [Volumetric Modulated arc Therapy] were employed for better target coverage and OARs [Organs at Risk] sparing. Due to cost-effectiveness and unavailability of advanced technological resources, 3DCRT[Three-Dimensional Conformal Radiotherapy Technique] is routinely employed.[4,5]] 3DCRT [Three-Dimensional Conformal Radiotherapy Technique] has the advantage of using multiple radiation fields

ISSN(O): 2687-5365; ISSN(P): 2753-6556

with targeted beams of radiation shaped to match the tumor size to deliver precise radiation and reduce the chances of irradiation to OARs [Organs at risk] such as lungs and heart, thereby sparing surrounding normal tissues.[13]

The Half –beam block[HBB] technique by a single isocentre decreases the occurrence of hot and cold spots. The Half- beam block technique has the advantage of sparing organs at risk [OAR'S],i.e.,underlying ipsilateral lung, contralateral lung, contralateral breast,and heart, in treating left-sided chest wall irradiation. Another advantage of this technique was field junction problems can be easily solved.The supra-clavicular field, internal mammary fields and tangents are set as half beams(use of asymmetric jaws), thereby providing no divergence at the junction. A single or mono-isocentre was placed at the junction of supraclavicular and tangential beams to treat chest wall irradiation, thereby reducing hot and cold spots.[12,27]

MATERIALS AND METHODS

Twenty patients with locally advanced left-sided breast carcinoma with involved IMN[Internal mammary node] who underwent left MRM[Modified radical mastectomy] followed by adjuvant chemotherapy and received left-sided chest wall irradiation at GAAMCH[Government Arignar Anna Memorial Cancer Hospital and Research Institute, Regional Cancer Centre]were retrospectively selected. Our retrospective analysis included patients with age more than 18 years, histologically confirmed infiltrating ductal carcinoma, locally advanced breast carcinoma, unilateral left chest wall and post left MRM[Modified Radical Mastectomy]patients.

Those who have evidence of distant metastasis or second malignancy, recurrent disease or underwent BCS[Breast conservation surgery] are excluded from the study. Planning Computed tomography (CT) scans from 20 patients previously treated were selected for this dosimetric study.

Patients underwent CT [Computed Tomography]simulation at 5mm slice thickness spacing, placed in the supine position on an angled breast board, with the left arm fully abducted(90 degrees or greater and externally rotated, and the head position was secured. The CT[Computed Tomography] images were transferred toTPS[Treatment Planning System] for radiotherapy treatment planning. For each patient, contouring was done [including PTV(Planning target volume) chest wall, PTV(Planning target volume) drainage,PTV(Planning target volume) internal mammary node, OARs[Organs at risk] like ipsilateral lung, heart,and contralateral breast. Treatment planning was done with three different 3DCRT[Three-Dimensional Conformal Radiotherapy Techniques] techniques for each contour which includes conventional3DCRT (Three-Dimensional Conformal Radiotherapy)techniques [Field-in-field, 3DCRT(Three-Dimensional Conformal Radiotherapy Technique)with wedge] were compared with Split tangential field half beam block technique.

The first technique involves the wedge technique; in this technique, a pair of opposing tangential fields were used to irradiate the chest wall. The dose modulation across the field is achieved using dynamic wedges, in which the jaws travel across the field to produce the desired wedge effect.

A second technique involves the standard Field – in –field [FIF]technique. Again, we have used the same pair of opposing tangential fields, but in this technique, MLCs [Multi leaf collimators] were used to provide dose modulation across the field. The advantage of this is that a customized dose modulation can be achieved using TPS [Treatment planning system] and MLCs [Multi leaf collimators], thereby improving dose homogeneity.

Third technique –Split field technique, the pair of opposing tangential fields, were divided into an upper and a lower tangential fields,i.e., a pair of upper tangents and a pair of lower tangents. Again, dose modulation is provided using MLCs [Multi leaf collimators] and subfields. Still, the advantage of this is better shielding of the lung and heart with the help of jaws instead of MLCs [Multi leaf collimators]. Also, different angulation of the upper and lower tangents helps in reducing the contralateral breast dose. A dose-volume histogram [DVH] was created for each patient's planning method. A dosimetric analysis was done, which includes target volume coverage, OAR [Organs at Risk] dose, maximum dose, mean dose, homogeneity index[HI] and conformity index [CI]by three different 3DCRT [Three-Dimensional Conformal Radiotherapy techniques] and then compared with tolerance doses.The conformity Index(CI) is the ratio between the volumes covered by a specific dose to the PTV [Planning Target Volume].The homogeneity index was calculated using the following formula HI= D5/D95, where D5 is the minimum dose in 5% of the target volume, and D95 is the minimum dose in 95% of the target volume.

RESULTS

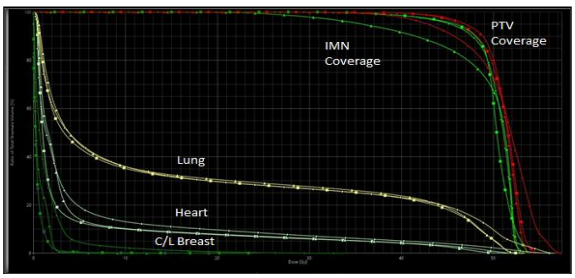

Figure 1: Dose-volume histogram curves for PTV [Planning Target Volume], ipsilateral lung, heart and contralateral breast for three different 3DCRT plans

ISSN(O): 2687-5365; ISSN(P): 2753-6556

The dosimetric parameters comparing three different 3DCRT[Three-Dimensional Conformal Radiotherapy] techniques assessed were Planning target volume parameters -PTV V95%, IMN V95%, DOSE max, Homogeneity index [HI], and Conformity index [CI] and Organs at risk [OARs] - Ipsilateral lung –V20Gy, Heart-V25Gy and contralateral breast mean dose.

[Figure 1] shows a dose volume histogram [DVH] comparison of three different three-dimensional conformal radiotherapy techniques[3DCRT] comprisedof split field half beam technique, field–in–field technique and 3DCRT with wedge technique. Red colour depicts PTV V95% coverage, dark green depicts IMN [Internal Mammary node] coverage, yellow - ipsilateral lung V20 and mean dose, blue – heart V25 and mean dose and light green – contralateral breast mean dose.

The triangular line depictsa Split field, Dotted line – Field –in-field technique and Squared line -Wedge technique.

This graph's triangular line depicting the split field technique shows better PTV and IMN coverage. OARs like ipsilateral lung, heart and contralateral breast mean dose were achieved within the normal, acceptable tolerance dose.

Table 1: Dose coverage of target [PTV]

PTV	WEDGE	STD FIF	SF
PTV V95%	88.36%	90.16%	95.39%
PTV Dmax	57.16Gy	56.58Gy	56.12Gy
IMN V95%	78.61%	83.69%	95.08%

[Table 1]show dosimetric comparison of the treatment volumefor the three planning techniques. Split tangential field half beam block technique shows better PTV dose coverage, at least95%coverage], IMN coverage and D maxdose was achieved within the acceptable limits compared to the other two techniques.

Table 2: Organs at risk [OAR]

Structures		Wedge	STD [FIF]	SF
LUNG	V20Gy	30.08%	30.00%	27.11%
	MEAN	15.74%	15.61%	14.22%
HEART	V25Gy	10.57%	10.70%	9.398%
	MEAN	7.060%	7.126%	5.174%
C/L BREAST	MEAN	0.70%	0.53%	0.37%

[Table 2] show dosimetric parameters of OARs [Ipsilateral lung, heart and contralateral breast] for three planning techniques that were assessed. The V20 lung doses were30.08, 30.00 and 27.11% for three different 3DCRT planning, respectively. In the split field technique, the low dose volume of ipsilateral lung V20 was < 30Gy, low dose volume of heart V25 was <10Gy,and mean doses of all OARs were achieved within the acceptable tolerance dose limits. The split field technique significantly reduced the high dose volume of the lungs[V20]and a reduction of the heart [V25] dose with a significant overall 10% reduction in dose compared to the other two techniques.

Table 3: Dose conformity [conformity index] and dose homogeneity [homogeneity index] of three different 3DCRT techniques

	WEDGE	STD [FIF]	SF
CI	1.019	1.056	1.013
HI	1.168	1.153	1.082

[Table3] shows conformity index [CI] and [HI] was compared with three different techniques in which the split field [SF]technique shows CI=1 shows the prescribed dose conforms to the target(PTV) volume and HI=1 shows better homogeneous dose distribution.

DISCUSSION

In this study, three different 3DCRT [Three-Dimensional Conformal Radiotherapy] planning techniques [Field- in-field technique, split tangential field half beam block, and 3DCRT with wedge] compared and dosimetric analysis and outcomes were investigated for left-sided chest wall [post mastectomy] patients.Twenty patients were retrospectively selected, and three plans were created for each patient contour. The split field HBB [Half Beam Block] technique becomes more useful when IMN [Internal Mammary Node] coverage is of prime importance. The upper tangents aim to encompass the IMN [Internal Mammary Node], while the lower tangents considerably save the OARs [Organs at Risk]. The split tangential field half beam block technique by using single isocentre shows better upper IMN[Internal Mammary Node] coverage and OAR[Organs at Risk] constraints significantly reduces the ipsilateral lung and heart–dose volumes and mean dose of contralateral breast. E Eklein et al shows technique using dual asymmetric jaws to beam- split all portals along the central axis plane and uses one isocentre to treat the

ISSN(O): 2687-5365; ISSN(P): 2753-6556

opposed tangential breast fields, the supraclavicular port and the posterior axillary field to achieve a perfect match-line, and set –up point, and supplie more absorption in reference to lung and contralateral breast dose.[12]

Especially in patients treated on the left side, those with pre-existing cardiovascular risk factors such as hypertension, obese individuals and those who receive Herceptin and other cardiotoxic agents such as anthracyclines, paclitaxel are likely to contribute to the development of radiation-induced cardiac events, so Split tangential field half beam block technique can be effectively used in these cases. For post-mastectomy radiotherapy of the left-sided chest wall, the Split tangential field HBB[Half Beam Block] technique significantly improves conformity of plan, good dose coverage, and reduced high dose volume of ipsilateral lung V20 and heart V25 by overall 10% reduction compared to Deep-Inspiration-Breath-Hold [DIBH] technique.

DIBH technique has dosimetric advantages to reduce excessive lung doses. Low-dose heart irradiation has not been successfully implemented due to the lack of breath hold apparatus in our radiotherapy unit; this was the major limitation of our study.3DCRT [Three-Dimensional Conformal Radiotherapy Technique] offers better dose homogenization and considerably decreases the radiation dose received by normal organs.An increased risk of second malignancy is especially seen in patients with higher advanced radiotherapy techniques like IMRT [Intensity Modulated Radiotherapy] and VMAT [Volumetric Modulated arc therapy]. Eric J Hall et al shows there is likely incidence of second malignancies for IMRT[Intensity Modulated Radiotherapy] compared with 3D-CRT due to dose distribution,i.e., a larger volume irradiated to lower doses. It is estimated that an additional0.5% of surviving patients will develop a second malignancy as a result of this factor.[21] Different 3DCRT [Three-Dimensional Conformal Radiotherapy] techniques are more likely to reduce the secondary cancer risk by reducing lung dose volume. A larger volume of normal tissue is irradiated with a lower dose.Vincent M Remou champs et al shows DIBH[Deep Inspiratory Breath Hold]technique significantly reduces heart and lung doses when especially tangential fields are used for Locoregional breast irradiation including IMNs and also IMRT [Intensity Modulated Radiotherapy] improves dose homogeneity, slightly reduces the dose to the heart, and diminishes the number of MUs required.[22] Further studies need to enhance DIBH [Deep Inspiratory Breath Hold technique] with 3DCRT[Three-Dimensional Conformal Radiotherapy Technique] approach.Furthermore, prospective studies with long follow-ups were needed to fully evaluate the secondary lung cancer risk and cardiac toxicity in left-sided breast carcinoma patients treated with different 3DCRT [Three-Dimensional ConformalRadiotherapy] techniques.

CONCLUSION

In this study, different dosimetric parameters of PTV [Planning Target Volume], as well as OAR [Organs at Risk], were analyzed for three different 3DCRT [Three-Dimensional Conformal Radiotherapy Technique] plans of left-sided PMRT [Post mastectomy Radiotherapy] cases. Split tangential field half beam block technique [splitting up the tangents] using single isocentre by 3DCRT [Three-Dimensional Conformal Radiotherapy Technique] ensures dosimetrically feasible and slightly provides more advantages for treating left-sided PMRT.This technique offers better left internal mammary node [IMN] coverage, PTV [Planning Target Volume] coverage, and better OAR [Organ at Risk] sparing or OAR [Organs at Risk] constraints than routine conventional 3DCRT [Three-Dimensional Conformal Radiotherapy technique].This can be a favourable option where mixed modality,complex treatments are not feasible to improveIMN[Internal Mammary Node] coverage. In centres with a high load of patients and resource constraints, this technique may be followed to reduce OAR[Organs at Risk] constraints. In turn, long-term complications of PMRT[Post Mastectomy Radiotherapy] will be reduced.

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ISSN(O): 2687-5365; ISSN(P): 2753-6556

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ISSN(O): 2687-5365; ISSN(P): 2753-6556