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# A Dosimetric comparison of IMRT versus 3D-CRT of chest wall in post mastectomy breast cancer patients: A Prospective Study.

**Oncology**

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| **Dr. Jayasree Kuna** | Senior Resident, Department of Radiation Oncology, Sri PleasrVenkateswara Institute of Medical Sciences (SVIMS), Tirupati, Andhrapradesh |
| **Dr. Pranabandhu Das** | Assistant Professor, Department of Radiation Oncology, Sri Venkateswara Institute of Medical Sciences (SVIMS) |
| **Dr.K.V.Jagannathrao Naidu** | Professor, Department of Radiation Oncology, Sri Venkateswara Institute of Medical Sciences (SVIMS) |
| **Dr. Swapna Jilla** | Assistant Professor, Department of Radiation Oncology, Sri Venkateswara Institute of Medical Sciences (SVIMS) |
| **Mrs Sangeetha Mani** | Physicist, Department of Radiation Oncology, Sri Venkateswara Institute of Medical Sciences (SVIMS) |
| **Dr. A.Y.Lakshmi** | Professor, Department of Radiology, Sri Venkateswara Institute of Medical Sciences (SVIMS) |
| **Dr. Amit Chowhan** | Associate Professor, Department of Pathology, Sri Venkateswara Institute of Medical Sciences (SVIMS) |
| **Dr.V.L.Anusha Konakalla** | Senior Resident, Department of Radiation Oncology, Sri Venkateswara Institute of Medical Sciences (SVIMS) |
| **Dr.B.Sreenivasa Rao** | Assistant Professor, Department of Radiation Oncology, Sri Venkateswara Institute of Medical Sciences (SVIMS) |
| **Dr. B.V.Subramanian** | Associate Professor, Department of Radiation Oncology, Sri Venkateswara Institute of Medical Sciences (SVIMS), Corresponding Author |

## ABSTRACT

**Background**

Evidence shows that Intensity modulated radiotherapy (IMRT) leads to better dose distribution than Three dimensional conformal radiotherapy 3DCRT for whole breast radiotherapy and for post mastectomy chest wall irradiation with internal mammary nodes . Data on the effect of IMRT of chest wall in post mastectomy breast cancer patients without internal mammary nodes IMN are scarce in literature.

**Methods and Material:**

For 30 Postmastectomy breast cancer patients, 7 field IMRT plan and tangential beam 3D-CRT plan were generated. The dose prescribed to PTV was 50 Gy in 25 fractions. The average values of the PTV parameters namely Dmean, HI, CI, D2, D50, D98 obtained by the two techniques (3D-CRT and IMRT) are compared.

**Results**

On comparison, D95(%) of PTV (3D-CRT 47.26 Gy; IMRT 48.37 Gy ($p<0.01$),HI and CI were significantly improved with IMRT. In Left chest wall irradiation, with IMRT V30 of heart was decreased from 23.31% to 18.99% ( p=0.075) and Dmean (14.05Gy 3D-CRT, 19.06Gy IMRT) was increased ($p<0.01$). V5 of heart was increased from 6.55% (3D-CRT) to 92.35% (IMRT) ($p<0.001$). Ipsilateral lung Dmean (21.13Gy 3D-CRT, 18.08Gy IMRT, p=0.07) and V20 (38.22% 3D-CRT, 35.14% IMRT p=0.006) decreased with IMRT. Low dose volumes of lung is increased with IMRT.

**Conclusions:**

The benefit is marginal in sparing OAR in post mastectomy chest wall without IMN radiation, which is achieved at a cost of increase in low dose volumes of lungs and heart. IMRT can be used in situations where strict constraints to the heart and lungs are not satisfied.

## KEYWORDS

IMRT, 3D-CRT, Post mastectomy breast cancer

## INTRODUCTION

Management of carcinoma breast includes multimodality approach which includes as breast conservation surgery (BCS) or mastectomy, systemic chemotherapy, hormonal therapy and adjuvant radiotherapy[1]. Because of anatomical convexity of chest wall, the standard bitangential photon beams may cause high doses to underlying organs, such as heart and lungs, which may lead to radiation-induced toxicities [2-9]. So newer modalities of radiation therapy techniques are evolved to reduce the toxicities of organ at risk and optimize the dose homogeneity to the target volume [10]. There is a sufficient evidence that IMRT leads to better dose distribution than 3DCRT of the whole breast radiotherapy after breast conserving surgery [11-16]. Data on the effect of IMRT of the chest wall in postmastectomy breast cancer patients are scarce in the literature[17-19]. This study is conducted to evaluate the dose distribution of IMRT of the chest wall in post mastectomy breast cancer patients in comparison to tangential beam 3D-CRT planning.

## MATERIAL AND METHODS

30 consecutive post mastectomy breast cancer patients came to our tertiary care center were included in the study. For RT planning and treatment patients were positioned on a breast board in supine position with both arms abducted and raised above the head and face turned to contra lateral to treating side. Patients were undergone CT simulation in Siemens somatom definition AS, 16 slice CT, Germany. CT images are acquired in 3mm slice thickness. Clinical target volume (CTV) and organ at risk (OAR) volumes were contoured as per RTOG atlas[20]. PTV was obtained by giving setup margin as appropriate to CTV.

Seven field IMRT plan and a standard tangential beam 3D-CRT plan were generated for the chest wall radiotherapy. The total dose prescribed to PTV was 50 Gy in 25 fractions @ 2Gy per fraction, 5 fractions per week with beam energy of 6 Mega Voltage (MV) using linear accelerator for all 3D-CRT and IMRT plans.3D-CRT plans were created in eclipse 8.1 planning system. Planning was done using mono isocenter technique, in which isocentre was kept at junction of the chest wall and the supra clavicular volumes. Medial and Lateral tangential fields planned with 6 MV photons covering the chest wall PTV. The anterior field edge should be in air by 2cm over the chest wall. To get homogenous dose distribution either wedge or field in field technique was also used. The posterior edges of the tangential beams are aligned. Blocking of the heart and lung are often achieved using multileaf collimation (MLC) to shape the posterior edge of the tangent beams Single anterior field or antero-posterior fields were used for the supra clavicular region. Pencil beam algorithm was used for the dose calculation. To increase the surface dose, virtual bolus of 1cm was used for the planning.

IMRT plans were generated with 7 fields using dynamic MLC sliding window technique in MONACO 5.0 planning system. For right chest wall cases, field angles starting from $60^0$ to $200^0$ with almost equal spacing were used. Similarly for left chest wall, angles starting from $300^0$ to $160^0$ were used. Virtual bolus of 1cm was used in the planning. The fields were fit to the combined PTV, which consisted of PTV chest wall and PTV supraclavicular region. Placement of the isocentre was at the centre of the combined PTV.

Evaluation of plans was based on dose volume histogram (DVH) analysis. Plans were evaluated according to International commission on radiation units and measurements (ICRU-83) criteria. For OARs, the analysis included the mean dose, the maximum dose and $V_{20}$,$V_5$ for lungs; mean dose, the maximum dose $V_{30}$, $V_5$ for heart; $D_2$,$D_{max}$ for spinal cord.Dose volume histograms of the PTV and organs at risk were generated for both the techniques and dose parameters compared. The Homogeneity index (HI) measures the degree of uniformity of dose distribution. The lower this value, the better is the dose homogeneity, which ranges 0-2.

$$HI= D_{2\%} - D_{98\%} / D_{50\%}.$$

The Conformity index (CI) measures the degree of isodose conformity to the PTV, and it is crucial in the treatment efficiency. A plan with a lower CI value, is more conformal, ranges 1-2.

$$CI=TV/ PTV$$

PTV=planning target volume covered by 98% of prescribed dose,
TV= treatment volume covered by 98% of prescribed dose.

The average values of the PTV parameters namely $D_{mean}$, HI, CI, $D_2$, $D_{50}$, $D_{98}$ obtained by the two techniques (3DCRT and IMRT) are compared using paired t-test with significance level $\alpha = 0.05$. The difference between the averages is considered as significant if $p < 0.05$.

All calculations are performed using SPSS Ver20.0 after entering the data in Microsoft office excel format 2007.

## RESULTS

Out of 30 patients in our study, 14 patients received right chest wall radiation and 16 patients received left chest wall radiation.

### PTV parameters

An improvement in the PTV coverage, HI and CI are improved with IMRT compared with 3DCRT , were shown in table 1**.**

### OAR parameters (Lungs, Heart and Spinal cord):

$V_{20}$ and $D_{mean}$ of ipsilateral lung were decreased with IMRT. low dose volumes($V_5$) of ipsilateral and contralateral lungs and contralateral lung $D_{mean}$ are increased with IMRT, it is shown in table 2. $V_{30}$ of heart is decreased, but it is not statistically significant. $V_5$ and $D_{mean}$ of heart increased with IMRT, as shown in table 3. Dose distribution of heart in left chest wall irradiation with IMRT and 3D-CRT technique are shown in table 4**.** Dmean, V5 of heart are increased with IMRT compared with 3D-CRT.V30 of heart was decreased with IMRT but statistically not significant. Spinal cord $D_{max}$ is significantly decreased with IMRT compared with 3D-CRT.

**Table 1- comparison PTV Parameters:**

| PTV Parameter | Mean 3D-CRT(Gy) | SD | Mean IMRT(Gy) | SD | Difference | Difference% | p-value |
|---|---|---|---|---|---|---|---|
| Mean Dose | 51.05 | 0.51 | 52.07 | 0.88 | -1.02 | 2 | <0.001 |
| HI | 0.21 | 0.07 | 0.15 | 0.04 | 0.05 | 25 | 0.001 |
| CI | 1.88 | 0.29 | 1.19 | 0.18 | 0.69 | 36 | <0.001 |
| D2% | 55.43 | 0.99 | 53.5 | 7.33 | 1.92 | 3.4 | 0.168 |
| D95% | 47.26 | 8.72 | 48.37 | 0.9 | -1.1 | 2.3 | <0.001 |
| D50% | 52.61 | 0.59 | 52.49 | 1.32 | 0.12 | 0.22 | 0.938 |
| D98% | 45.77 | 2.07 | 47.1 | 1.55 | 0.67 | 1.4 | 0.007 |

Homogeneity Index (HI), Conformity Index (CI), D2% (dose received by 2% of the volume), D95%(dose received by 95%% of the volume), D50%(dose received by 50% of the volume), D98%(dose received by 2% of the volume).

**Table 2: Plan parameters by IMRT and 3D-CRT techniques of the lungs.**

| Organ Parameter | 3D-CRT Mean | SD | IMRT Mean | SD | Difference | Difference% | p - value |
|---|---|---|---|---|---|---|---|
| IL LUNG Dmean(Gy) | 21.13 | 8.67 | 18.08 | 2.52 | 3.03 | 14.33 | 0.007 |
| IL LUNG V20(%) | 38.22 | 5.24 | 35.14 | 5.66 | 3.08 | 8.05 | 0.006 |
| IL LUNG V5(%) | 49.67 | 5.16 | 72.12 | 13.51 | 22.45 | 45.2 | <0.001 |
| CL LUNG Dmean(Gy) | 1.23 | 2.15 | 6.45 | 1.59 | -5.22 | 428.67 | <0.001 |
| CL LUNG V5(%) | 0.40 | 0.72 | 57.13 | 20.43 | -56.73 | 14182 | <0.001 |

Dmean (mean dose). $V_{20}$ and $V_5$ represents the percentage of lung receiving 20 and 5 Gy respectively. IL- ipsilateral, CL- contralateral

**Table 3: Plan parameters by IMRT and 3D-CRT techniques of the heart.**

| Organ Parameter | 3D-CRT Mean | SD | IMRT Mean | SD | Difference | Difference% | p-value |
|---|---|---|---|---|---|---|---|
| Heart Dmean | 12.83 | 10.02 | 15.39 | 4.89 | -2.56 | 19.95 | 0.172 |
| Heart V30% | 12.69 | 12.68 | 10.82 | 11.51 | 1.88 | 14.8 | 0.159 |
| Heart V5% | 24.54 | 19.91 | 90.77 | 17.46 | -66.23 | 269.99 | <0.00 |

Dmean (mean dose). $V_{30}$ and $V_5$ represents the percentage volumes of the normal organs receiving 30, and 5 Gy respectively.

**Table 4: Dose distribution of heart in IMRT and 3D-CRT technique of left chestwall.**

| Heart | 3D-CRT | IMRT | - value |
|---|---|---|---|
| Dmean(Gy) | 14.0562 | 19.0569 | <0.001 |
| V30 (%) | 23.2131 | 18.9881 | 0.075 |
| V5 (%) | 40.2681 | 89.3712 | <0.001 |

Dmean (mean dose). $V_{30}$ and $V_5$ represents the percentage volumes of the normal organs receiving 30, and 5 Gy respectively.

## DISCUSSION

The present study showed significant improvement in target coverage with IMRT when compared with 3D CRT, which was also reported by Vishruta et al. [21] and Koshy et al. [22] who included IMN as part of partial wide tangential field irradiation. In our study, there is a significant decrease in near maximum dose ($D_2$) and improvement in the HI and CI. Similar to our study, Kreuger et al. [23] showed that dose uniformity was improved with IMRT. Study by Koshy et al. [22] showed decrease in $V_{110\%}$(volume receiving 110% of prescribed dose) which is equivalent to D2 in our study and decreased dose heterogeneity and occurrence of hot spots with IMRT when compared to PWT-3DCRT (partially wide tangential -3DCRT). With older techniques of RT, beneficial effect was compensated by a 30% increase in cardiac morbidity [24]. Coronary events increase linearly by 7.5% per Gray to the heart with no apparent threshold. Hence even single Gray decrease in cardiac dose can decrease the coronary events and there by cardiac morbidity and mortality[25-27]. So the task of minimizing cardiac dose became essential in radiotherapy planning.

In our study, patients who received left side chest wall irradiation, with IMRT, $V_{30}$ of heart was decreased from 23.31% to 18.99%( p=0.075) and $D_{mean}$ (14.05Gy by 3D-CRT, 19.06Gy by IMRT) was increased (p<0.01). Koshy et al.[22] who compared dosimetric parameters of left chest wall irradiation, showed that there was decrease in $V_{30}$ of the heart by IMRT which was 2.3% by IMRT compared to 7.5% by PWT 3D-CRT(p=0.01), which was statistically significant. High dose volume of heart ($V_{30}$) was decreased which was comparable with our study. In contrast to our study, Kreuger et al. [23] showed that there was no difference in $V_{30}$ of heart on comparison of IMRT and PWT 3D-CRT (0.12% versus 0.40%), $p$=0.28. This may be because in Krueger et al study volume of heart receiving 30Gy ($V_{30}$) was minimal in both techniques.In our study, on evaluation of right chest wall irradiated patients, $D_{mean}$ of the heart was almost equal with both the techniques. $V_{30}$ of heart was negligible with both the techniques . Low dose volume, $V_5$ of heart was increased from 6.55% (3D-CRT) to 92.35% (IMRT). In Contrast to our study, a study by Vishrutha et al.[21] who compared IMRT and 3D-CRT of right chest wall, IMN and supraclavicular nodal irradiation $D_{mean}$ of the heart was increased with IMRT from 1.19 Gy to 6.17Gy. V20 (0% in 3D-CRT, 3.87% in IMRT) was also increased with IMRT. The dose received by heart is very minimal by both the techniques, even though it was increased slightly with IMRT. This may be due to multiple fields which also directed through the contralateral side of the treated volume. So heart will be exposed to some amount of minimal dose. There may be benefit of IMRT in decreasing V30 in the left sided chest wall irradiation as tangential beams pass through large volumes of heart. But in right sided chest wall irradiation studies did not show any benefit in heart sparing.

In our study low dose volume ($V_5$) of irradiated heart was increased in left sided chest wall irradiation. Similar to our study, Kreuger et al.[23] study, Koshy et al. [22] studies also showed increase in low dose volumes of heart IMRT. So in left sided chest wall irradiation there is decreased $V_{30}$ at a cost of increased low dose volumes of heart.In our study, on evaluation of right side chest wall irradiation, low dose volumes of heart irradiated more by IMRT technique compared to 3D-CRT. Similar to our study by Vishrutha et al. [21] also V10 (0% in 3D-CRT, 13.67% in IMRT) was increased with IMRT. Hence in right side chest wall irradiation there was no decrease in high dose volume of heart but increase in low dose volume.Incidence of symptomatic pneumonitis after standard tangential fields radiotherapy is $\leq$5% of patients treated, which is usually acceptable. If patients were treated with PWT to include IMN, there will be high chances of pneumonitis as large amount of lungs will be included. But as we did not include IMN nodes, treated with standard tangential beams in 3D-CRT, the lung dose is acceptable.In our study ipsilateral lung Dmean and V20 were decreased with IMRT. Low dose volumes of lung is increased with IMRT. In a similar study with Krueger et al. [23] with IMRT mean dose to lungs ($D_{mean}$) decreased from 17.6Gy to 9.5Gy when compared with PWT and low dose volumes of lungs increased with IMRT. In similar studies by in Koshy et al. [22] $V_{20}$ (38.4% with 3D-CRT to 29% with IMRT) was decreased with IMRT and low dose volumes are increased. Similar results were found with Vishrutha.et.al study also who did study on right chest wall irradiation.

In our study contra lateral lung doses were increased with IMRT compared with 3D-CRT. .Studies by Kreuger et al.[23], Koshy et al.[22], Vishrutha et al.[21] also showed increased in low dose volumes. High dose volumes of lung were decreased at a cost of increased low dose volume of ipsilateral and contra lateral lungs with IMRT compared with 3D-CRT.

Limitations of present study were such as there was no correlation of the improved dosimetry with clinical outcome and few similar background studies for comparison of our study.

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