Comparison of Dosimetric Parameters of Three-Dimensional Conformal Radiotherapy and Intensity-Modulated Radiotherapy in Breast Cancer Patients Undergoing Adjuvant Radiotherapy after Modified Radical Mastectomy

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Abstract

Introduction Adjuvant radiotherapy has an important role in preventing locoregional recurrences. But radiation-induced late sequelae have become an important area of concern. The ideal postmastectomy radiotherapy technique is an area of controversy. The present study was designed to compare two widely practiced conformal techniques, three-dimensional conformal radiotherapy (3DCRT) and intensity-modulated radiotherapy (IMRT), in terms of dosimetry.

Material and Methods A total of 50 postmodified radical mastectomy patients were selected and were randomized to treatment either by 3DCRT or IMRT technique. Two opposing tangential beams were used in 3DCRT plans whereas five to seven tangential beams were used for IMRT plans. The prescribed dose was 50 Gy in 25 fractions over 5 weeks. The dosimetric parameters were compared for planning target volume (PTV), lungs, heart, and left ventricle, opposite breast and esophagus.

Results The dosimetric parameters of PTV in terms of $D_{95\%}$, $D_{90\%}$, $D_{50\%}$, and D_{mean} showed no significant difference among both techniques. The IMRT technique had significantly better mean values of $D_{near\text{-}min}/D_{98\%}$ (45.56 vs. 37.92 Gy; $p = 0.01$) and $D_{near\text{-}max}/D_{2\%}$ (51.47 vs. 53.65 Gy; $p < 0.001$). Also, conformity index (1.07 vs. 1.29; $p = 0.004$) and homogeneity index (0.22 vs. 0.46; $p = 0.003$) were significantly better in IMRT arm.

The dosimetric parameters of ipsilateral lung were significantly higher in IMRT arm in terms of mean dose (19.92 vs. 14.69 Gy; $p < 0.001$) and low/medium dose regions (V_5, V_{10}, V_{13}, V_{15}, V_{20}; $p < 0.05$). However, high-dose regions (V_{40}) were significantly higher in 3DCRT arm (15.57 vs. 19.89 Gy; $p = 0.02$). In contralateral lung also, mean dose was significantly higher in IMRT technique (3.63 vs. 0.53 Gy; $p < 0.0001$) along with low-dose regions (V_5, V_{10}, V_{13}, V_{15}; $p < 0.05$) while V_{20} was comparable between both the arms.

Keywords
- 3DCRT
- IMRT
- modified radical mastectomy

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In left-sided patients, the heart dose favored 3DCRT technique in terms of mean dose (17.33 vs. 8.51 Gy; $p = 0.003$), low/medium dose regions (V_5, V_{10}, V_{20}; $p < 0.05$), and doses to partial/whole volumes (D_{33}, D_{67}, D_{100}). But the high-dose regions (V_{25}, V_{30}, V_{40}) were comparable between both the arms. The dosimetry of left ventricle also showed significantly lesser values of mean dose and V_5 in 3DCRT technique ($p < 0.0001$).
The opposite breast also showed higher mean dose with IMRT technique (2.60 vs. 1.47 Gy; $p = 0.009$) along with higher V_5 (11.60 vs. 3.83 Gy; $p = 0.001$). The dosimetric parameters of esophagus showed higher mean dose in IMRT technique (10.04 vs. 3.24 Gy; $p < 0.0001$) but the high-dose regions V_{35} and V_{50} were comparable between both the arms.
Conclusion A clear advantage could not be demonstrated with any of the techniques. The IMRT technique led to more conformal and homogenous dose distribution with reduction in high-dose regions in ipsilateral lung while the 3DCRT technique showed lesser mean dose to organs at risk (OARs). The exposure of large volumes of OARs to low doses in IMRT technique may translate to increased long-term radiation-induced complications. The shortcomings of 3DCRT technique can be overcome by using multiple subfields within tangential fields.

Introduction

Globally, the incidence of breast cancer has surpassed all other malignancies.[1] In India, locally advanced breast cancer is seen in a large proportion of women where postmastectomy radiotherapy plays a key role in the adjuvant treatment.[2,3] Newer radiotherapy techniques have evolved and is being regularly practiced since last decade. The advent of intensity-modulated radiotherapy (IMRT) technique allowed huge improvement in planning and outcomes of head and neck, prostate, and various other sites over the existing conformal techniques, but its role in breast cancers has not been clearly defined. The evolution of radiotherapy techniques is based on increasing the local control and reducing the side-effects to the adjacent organs. The prognosis of breast cancer has improved substantially in previous decades.[4] Long-term morbidity is a concern for every oncologist. The concept of radiotherapy planning in postmastectomy breast cancer is focused to deliver optimum dose to the chest wall and regional lymph nodes with minimum dose to the heart, both lungs, contralateral breast, and esophagus. An increasing number of cardiac substructures such as left ventricle and coronary arteries have gained significant attention demanding further improvisation of the existing planning practices.[5,6]

The conventional radiotherapy techniques delivered optimum dose to the chest wall and regional drainage area (clinical target volume [CTV]) but could not restrict the doses to organs at risk (OARs) to minimum. Newer radiotherapy techniques like three-dimensional conformal radiotherapy (3DCRT) and IMRT have shown an important role in this regard. Data on ideal postmastectomy radiotherapy technique among the two widely practiced conformal techniques remain a long-standing controversial issue. The 3DCRT technique offers better distribution of the prescribed dose at the target volume compared with conventional technique; however, the intensity of radiation is uniform in each beam leading to similar dose delivery to the tumor and adjacent OARs inside the target treatment volume. Comparatively, the inverse IMRT technique allows a nonuniform deposition of the dose at the treatment target with better homogeneity and conformity, but the multibeam arrangement utilized leads to an indispensable rise in entry dose and the low-dose volumes.

The present study was designed to compare the two widely practiced conformal techniques, 3DCRT and IMRT, in terms of dosimetric parameters of planning target volume (PTV) and OARs in postmastectomy breast cancer patients.

Materials and Methods

A total of 50 breast carcinoma patients who underwent modified radical mastectomy were enrolled in this prospective randomized control trial from November 2017 to March 2019. By simple randomization, an equal number of patients were allocated to treatment either by 3DCRT technique or IMRT technique. Patients with synchronous or bilateral breast carcinoma, metastatic disease, previous history of thoracic radiation, and with positive surgical margins were excluded from the study.

Radiotherapy Planning

Simulation

For simulation, patients were immobilized in supine position on a semi-inclined breast board with both arms extended above the head, flexed at the elbow joint, and externally rotated. Contrast-enhanced computed tomography scan of the thorax with 3 mm slice thickness was obtained. Radio-opaque markers were used to mark the inferior and lateral borders of the chest wall and surgical scar mark.

Volume Delineation

The delineation was done as per Radiation Therapy Oncology Group (RTOG) breast contouring guidelines.[7] The CTV comprised of chest wall and regional lymph nodes. The PTV was defined as 5 mm isotropic expansion of the CTV. The OARs delineated were both lungs, heart, left ventricle, contralateral breast, esophagus, and spinal cord. The delineation of left ventricle was done as per cardiac contouring atlas.[8] For spinal cord, a planning risk volume (PRV) margin of 5 mm was given from the spinal cord.

3DCRT Planning

In 3DCRT plans, two tangential beams were used from either side of chest wall. The angles were defined using the Beam's Eye View that allowed minimal inclusion of adjacent OARs in the radiation portal. The plans were optimized using varying weightage of beams, field in field (FiF), and enhanced dynamic wedges. For nodal irradiation, a single anterior field was used with mono-isocentric half beam block technique for supraclavicular lymph nodes.

IMRT Planning

A total of five to seven tangential beams were used for chest wall and nodal volumes. The beam orientation was so chosen to minimize the entry path traversed through adjacent OARs. Inverse planning was done in the beam optimization process considering tissue inhomogeneities using a progressive resolution optimizer algorithm. The calculation was performed by the analytical anisotropic algorithm. The maximum iteration limit was 1,000 and the iteration time given was 1,000 second with a resolution of 2.5 mm. Normal tissue objective was modified for these plans. The plans were calculated using dynamic multileaf collimator and jaw-tracking tools.

Dose Prescription

A dose of 50 Gy in 25 fractions was prescribed to the PTV using 6 MV photon energy.

Dosimetric Assessment

The planning objectives were defined to accept the PTV dose primarily ranging from 95% to 107% relative to the prescription. A total of 90% of prescribed dose to 90% of the volume and an upper limit of 110% was also considered acceptable.

The dose constraints to the OARs were prescribed as per recommended by Quantitative Analyses of Normal Tissue Effects in the Clinic (QUANTEC),[9,10] RTOG,[11] and Danish Breast Cancer Cooperative Group,[12] and were individualized for each OAR as per departmental protocol.

Ipsilateral lung: D_{mean} < 20 Gy, V_{20} < 35%; Heart (left-sided patients): D_{mean} < 15 Gy, V_{25} <10%; 1[3] Opposite breast: V_5 < 5%; Esophagus: D_{mean} < 34 Gy, V_{35} <50%; PRV spine: $D_{max} \le 50$ Gy.

The dose to left ventricle was evaluated retrospectively but no constraint was prescribed.

Dosimetric Analysis

Dose volume histograms and dose color wash were compared among the two planning techniques. The dosimetric parameters assessed were: PTV (D_{95}, D_{90}, D_{50}, D_{mean}, V_{107}, D_2 [$D_{near\text{-}min}$], D_{98} [$D_{near\text{-}max}$], homogeneity index [HI], and conformity index [CI]); ipsilateral lung (V_5, V_{10}, V_{13}, V_{15}, V_{20}, V_{25}, V_{40}, and D_{mean}); contralateral lung (V_5, V_{10}, V_{13}, V_{15}, V_{20}, D_{mean}); heart ($D_{33\%}$, $D_{67\%}$, $D_{100\%}$, V_5, V_{10}, V_{20}, V_{25}, V_{30}, V_{40}, and D_{mean}); left ventricle (V_5, D_{mean}); opposite breast (V_5, D_{mean}); and esophagus (V_{35}, D_{mean}).

The HI and CI were calculated as per International Commission on Radiation Units and Measurements (ICRU) 83[14] and ICRU 62,[15] respectively.

Statistical Significance

The statistical significance was calculated by using *t*-test of unequal variances. A *p*-value of < 0.05 was considered statistically significant.

Ethical Considerations

The study was approved by the Institutional Ethical Review Committee before its inception. A written informed consent was obtained from each patient prior to participation in study.

Results

The distribution of the various patient factors and tumor factors has been shown in ►**Table 1**.

The prevalence of left-sided breast cancer was far less than that of right-sided one among both the groups. The

Table 1 Patient characteristics (*n* = 50)

Characteristics	3DCRT	IMRT
Age (y)		
Mean	45	52
Median	45	53
Laterality	Number of patients: *n* (%)	
Left sided	7 (28)	11 (44)
Right sided	18 (72)	14 (56)
Menopausal status		
Premenopausal	7 (28)	7 (28)
Perimenopausal	6 (24)	4 (16)
Postmenopausal	12 (48)	14 (56)
Histopathology		
Not otherwise specified	22 (88)	22 (88)
Medullary carcinoma	2 (8)	3 (12)
Lobular carcinoma	1 (4)	0 (0)
Coexistence of ductal carcinoma in situ	18 (72)	6 (24)
Lymphovascular invasion present	12 (48)	13 (52)
Nottingham grade		
Grade 1	4 (16)	4 (16)
Grade 2	13 (52)	9 (36)
Grade 3	5 (20)	8 (32)
Not known	3 (12)	4 (16)

Abbreviations: 3DCRT, three-dimensional conformal radiotherapy; IMRT, intensity-modulated radiotherapy.

predominant histopathology was of “Not otherwise specified” variety observed in 88% of the patients in both the groups.

The various dosimetric parameters of PTV are shown in ►**Table 2**.

The 3DCRT and IMRT techniques proved to be comparable in terms of coverage of target volume of interest. The D_{90}, D_{95}, D_{mean}, and D_{50} reflected better coverage in IMRT group but the difference was not statistically significant. Further, in both the techniques, dosimetric coverage was acceptable with nearly 90% of the volume covered by 90% of the prescribed dose. The IMRT technique demonstrated statistically significantly advantage in dose conformity and homogeneity attributable to a significantly higher value of $D_{near\text{-}min}$ and lesser value of $D_{near\text{-}max.}$ The volume receiving more than 107% of the prescribed dose was higher in 3DCRT arm than IMRT arm (5.03 vs. 0.03%; $p < 0.01$; ►**Table 2**).

The comparison of dosimetric parameters of OARs is shown in ►**Table 3**. The dose constraint of PRV spine less than 50 Gy was met in all the plans. The recommended dose constraints for ipsilateral lung showed significant advantage (V_{20}: 29.45 vs. 36.82, $p = 0.009$; D_{mean}: 14.69 vs. 19.92, $p < 0.001$) with 3DCRT technique. On comparing the dosimetric parameters of contralateral lung, nearly no dose was seen in 3DCRT plans while low doses were being delivered in IMRT plans, which were statistically significant.

On evaluating other dose parameters of ipsilateral lung (V_5, V_{15}), there was a significant difference in low-dose volumes of lung being irradiated with 3DCRT technique. However, the volume of ipsilateral lung receiving high doses (V_{40}) was more with 3DCRT technique, which was statistically significant.

As per the prescribed dose constraints for opposite breast, we could not meet the criteria in IMRT arm but was achievable in 3DCRT arm. The difference in volume

Table 2 Dosimetric parameters of planning target volume (volume in percentage; dose in Gy)

Parameters	Variable	3DCRT	IMRT	*p*-Value
PTV	$D_{95\%}$	38.61 ± 9.10	43.21 ± 11.37	0.121
	$D_{90\%}$	44.71 ± 2.82	48.38 ± 10.08	0.672
	D_{mean}	49.63 ± 1.46	49.67 ± 2.55	0.424
	$D_{50\%}$	49.64 ± 1.16	49.67 ± 1.53	0.918
	$D_{2\%}$ ($D_{near\text{-}max}$)	53.65 ± 1.03	51.47 ± 1.59	<0.001
	$D_{98\%}$ ($D_{near\text{-}min}$)	37.92 ± 13.8	45.56 ± 11.65	0.012
	$V_{107\%}$	5.03 ± 1.17	0.03 ± 0.07	<0.001
	CI	1.29 ± 0.32	1.07 ± 0.18	0.004
	HI	0.46 ± 0.28	0.22 ± 0.27	0.003

Abbreviations: 3DCRT, three-dimensional conformal radiotherapy; CI, conformity index; HI, homogeneity index; IMRT, intensity-modulated radiotherapy; PTV, planning target volume.

Table 3 Dosimetric parameters of lungs, opposite breast, and esophagus (volume in percentage; dose in Gy)

Parameters	Variable	3DCRT	IMRT	*p*-Value
Ipsilateral lung	V_{20}	29.45 ± 7.48	36.82 ± 11.41	0.009
	D_{mean}	14.69 ± 3.46	19.92 ± 3.52	<0.001
	V_5	47.60 ± 10.11	87.36 ± 15.19	<0.001
	V_{10}	33.92 ± 8.29	71.28 ± 17.47	<0.001
	V_{13}	32.17 ± 7.90	60.65 ± 17.13	<0.001
	V_{15}	31.29 ± 7.75	53.26 ± 15.95	<0.001
	V_{25}	27.73 ± 7.29	28.90 ± 8.71	0.608
	V_{40}	19.89 ± 6.46	15.57 ± 6.39	0.021
Contralateral lung	V_5	0.001 ± 0.003	26.32 ± 31.33	<0.001
	V_{10}	0 ± 0.00	71.27 ± 13.03	<0.001
	V_{13}	0 ± 0.00	60.65 ± 3.71	<0.001
	V_{15}	0 ± 0.00	0.78 ± 1.61	0.024
	V_{20}	0 ± 0.00	0.06 ± 0.26	0.251
	D_{mean}	0.53 ± 0.18	3.63 ± 2.78	<0.001
Opposite breast	V_5	3.83 ± 4.50	11.61 ± 10.06	0.001
	D_{mean}	1.47 ± 1.36	2.61 ± 1.58	0.009
Esophagus	V_{35}	3.03 ± 6.13	3.43 ± 6.23	0.824
	D_{mean}	3.24 ± 3.10	10.04 ± 6.14	<0.001

Abbreviations: 3DCRT, three-dimensional conformal radiotherapy; IMRT, intensity-modulated radiotherapy.

receiving low doses (V_5) was also statistically significant. The mean dose of esophagus was far lesser than the dose constraint. Comparatively, the mean dose was observed to be thrice higher in IMRT technique despite comparable high-dose volumes (V_{35}) reflecting the probability of some impact of low-dose volumes (►**Table 3**).

In total, there were 18 patients of left-sided breast cancer who were planned by 3DCRT (n = 7) or by IMRT technique (n = 11). The dosimetric parameters of heart and left ventricle are shown in ►**Table 4**. As per QUANTEC guidelines, none of the techniques could achieve the dose constraint of V_{25} < 10% (3DCRT, 14.42 Gy; and IMRT, 26.11 Gy). Another dose constraint of D_{mean} < 15 Gy was achieved by 3DCRT technique but not by IMRT technique. The difference in D_{mean} was statistically significant and lower in 3DCRT technique (8.51 vs. 17.33; p = 0.003). At different low doses, the volume of heart irradiated showed statistically significant reduction with 3DCRT planning compared with IMRT planning (V_5, V_{10}, V_{20}). Similarly, doses received by one-third, two-thirds, and whole volume of heart was significantly lesser in 3DCRT technique. On evaluating the V_5 and D_{mean} of left ventricle, the 3DCRT technique showed significantly better dosimetry.

Discussion

The study did not reveal any statistically significant difference in terms of coverage of the target volume among both the techniques. However, the flaws of 3DCRT technique were coverage of superficial build-up region of chest wall, nodal volumes, junctional dose, and dose spillage beyond edges of the chest wall. The anatomy and the delineated nodal region varied enormously and the prescription at maximum depth did not either optimally cover intended targets or led to dose spillage in apex of lung that was largely responsible for the increase in high-dose volumes of ipsilateral lung reflected by V_{40} parameter in 3DCRT plans. Comparatively, in IMRT plans, the multibeam arrangement ensured adequate build-up thickness from all directions allowing better coverage of superficial regions of chest wall. The nodal volume dosimetry was also improved with avoidance of the complexity of junctional dose.

The better conformity of IMRT plans allowed sparing of high-dose volumes of lung but the multibeam arrangement led to inevitable rise in entry dose, low-dose, and also medium-dose volumes (V_5, V_{10}, V_{13}, and V_{15}). Henceforth, its impact on mean lung dose was detrimental. Although V_{20} and mean dose have traditionally been considered as a predictor of radiation-induced pneumonitis, emerging data suggest robust correlation with further lower-dose volumes also. A study by Schallenkamp et al proved low-dose volumes, V_{10}, and V_{13} to be better predictors of pneumonitis risk with a decline in predictive values above these volumes (V_{15}, V_{20}, V_{30}, mean dose).[16] Although strong evidence is presently lacking to support routine evaluation of low-dose lung volumes, this certainly favors 3DCRT technique with possibility to translate into better clinical outcomes.

Our study also proved better cardiac sparing in terms of mean-dose and low-dose volumes with 3DCRT techniques. This remains largely controversial as few authors have validated the findings of our study[17,18] while many have contradictory the results.[13,19] There is a possibility that use of "deep inspiration breath holding" (DIBH) mode and minimizing the beams may also lead to better exploitation of the conformity in IMRT technique. But there is a growing concern about the enormous impact of low-dose volumes, which is an inevitable disadvantage of the IMRT technique. A recent predictive model by van den Bogaard et al proved V_5 of left ventricle to be a better predictor of acute coronary events than other parameters (V_{10} to V_{60} and mean heart dose) over 9 years of follow-up.[6] There are limited data on impact of technique on dosimetry of left ventricle. Given its strong clinical correlation, further research is warranted.

Although the contralateral lung, esophagus, and opposite breast received minimal doses with both the techniques, the huge and significant rise with IMRT technique may translate into an increased risk of second malignancies.

A large-scale systematic review by Aznar et al also proved substantial increase in contralateral lung dose with IMRT over simple tangents irrespective of inclusion of nodal

Table 4 Dosimetric parameters of heart and left ventricle in left-sided patients (volume in percentage; dose in Gy)

Parameters	Variable	3DCRT	IMRT	p-Value
Heart	D_{mean}	8.51 ± 4.78	17.33 ± 5.53	0.003
	V_{25}	14.42 ± 10.44	26.11 ± 10.44	0.070
	D_{33}	6.86 ± 10.10	19.53 ± 6.90	0.015
	D_{67}	1.54 ± 0.59	9.92 ± 6.09	0.001
	D_{100}	0.53 ± 0.26	2.85 ± 2.27	0.007
	V_5	23.56 ± 13.07	83.83 ± 13.06	<0.001
	V_{10}	18.67 ± 11.75	60.62 ± 11.75	<0.001
	V_{20}	15.69 ± 10.75	34.21 ± 10.75	0.024
	V_{30}	13.21 ± 10.08	18.85 ± 10.08	0.261
	V_{40}	10.27 ± 8.44	9.05 ± 8.44	0.750
Left ventricle	D_{mean}	14.63 ± 5.84	22.01 ± 5.44	0.019
	V_5	42.83 ± 16.03	97.12 ± 5.56	<0.001

Abbreviations: 3DCRT, three-dimensional conformal radiotherapy; IMRT, intensity-modulated radiotherapy.

volumes.[20] Although less concern has been laid on esophageal toxicities in breast cancer survivors, there is growing concern of second malignancies, demanding consideration of rising low-dose volumes in IMRT technique.

Contrary to our study, Rudat et al showed IMRT technique to have significantly better conformity and better lung sparing with a reduction in the mean dose by 21%, reduction of 20% in mean heart dose, and reduction of 43% in V_{35} in left-sided patients, compared with 3DCRT technique.[19] The possible reason for better cardiac and lung sparing is that the same tangential two-beam arrangement was used for both the techniques. However, in our study the use of multibeam arrangement in IMRT plans increased the entry dose masking the effect of better conformity on OAR sparing. But this led to significantly better dose homogeneity in IMRT plans in our study while it was nearly comparable in their study among both the techniques.

A study by Rastogi et al also proved superiority of IMRT technique in terms of significantly better conformity but comparable dose homogeneity, and reduction in the high-dose volumes of lung (V_{20}, V_{55}) and heart (V_{25}, V_{45}) along with their mean doses. The reason for contrary findings may be the use of slightly higher number of beams, that is, five to seven in our study compared with four to six beam arrangements in their study. However, a consistent detrimental impact on low-dose volumes was observed among both the studies.[13]

A study by Aras et al comparing simple tangential beams in 3DCRT with nine-beam nonreciprocal IMRT plans in left-sided patients showed significant improvement in conformity with IMRT plans. A significant reduction in the high-dose volumes of lung, that is, V_{30}, was seen with IMRT plans but at the expense of significant rise in the low-dose volumes V_5 and V_{10} that was observed, in accordance with our study. Conversely, the mean dose and V_{20} were observed to be lesser in 3DCRT plans similar to our findings, but their study could not demonstrate statistical significance. In their study, the dose to partial volume, D_{33}, of heart was significantly lesser with 3DCRT technique ($p = 0.00$) with nonsignificant reduction in mean dose.[18] This validates the findings of our study that not much of additional advantage is obtained with IMRT plans over 3DCRT plans if relatively higher number of beams are utilized owing to increment in entry dose with each successive beam added.

A recent study by Finazzi et al of 332 left-sided breast cancer patients showed a significant rise in mean dose of heart, ipsilateral lung, and V_{20} of the left lung ($p < 0.01$) with IMRT compared with 3DCRT. A subgroup analysis of patients treated without nodal irradiation also proved a significant disadvantage with IMRT technique for ipsilateral mean lung dose and V_{20} ($p < 0.01$) but with comparable heart doses. Their institutional time trends showed increase in nodal irradiation to 37.5% in year 2015 to 2018 compared with 25.0% in 2013 to 2014. Despite detrimental impact on dosimetry of OARs, the use of IMRT/volumetric modulated arc therapy technique showed a drastic rise to 46.0% in year 2015 to 2018 compared with only 5.6% in 2013 to 2014.[21]

Our study showed that IMRT technique owing to its more conformal nature allowed custom tailoring of high-dose volumes to the PTV minimizing the exposure of superficial lung tissue to high doses. But the accompanying disadvantage was exposure of large volumes of lung, heart, and opposite breast to low doses that increased the mean dose as well over 3DCRT technique. This raises concern of long-term radiation-induced second malignancies. Also, emerging evidences have proved robust correlation of lower doses with pulmonary and cardiac morbidity. These findings of our study highlighting disadvantage of IMRT technique in terms of low-dose volumes have been validated across most of the studies.

In the present study, only one pair of subfields was used in few of the 3DCRT plans. A higher number of subfields with manual iterations reducing weightage in overdosed regions and increasing weightage in the underdosed region can possibly overcome the shortcomings of 3DCRT technique. Tanaka et al compared three methods of FiF planning, that is, single pair of subfields, three pair of subfields, or alternate pair of subfields. In the alternate subfield method, total five fields were used including main fields and subfields. The subfields were added in a serial manner and the dose calculation was performed after adding a single subfield to one of the tangential fields. In the other two methods, subfields were added to both the tangentials and then dose calculation was performed. The average $V_{100\%}$, that is, the volume receiving the prescribed dose with alternate subfield method, was significantly higher than with single or multiple pair of subfields. But the average D_{max}, $V_{95\%}$, and HI did not differ significantly among the three methods. Remarkably, in their study the maximum HI was observed with single pair of subfields, which was only 0.109 ± 0.02, but in our study, the mean value of HI was comparatively higher, that is, 0.46 + 0.28. Also, the planning time was relatively lesser compared with the other two methods.[22] Helal and Elbatikhy compared simple tangential fields to forward IMRT plans having five segments in two tangential fields. The segment one covered the PTV, segment two included PTV and excluded heart, segment three included PTV and excluded lung, segment four included PTV and excluding both heart and lung, and segment five included PTV and excluded build-up region. The IMRT plans led to significant reduction in heart and lung doses and better dose homogeneity (p-value < 0.001) over the simple tangentials.[23]

The findings of the two studies highlight that FiF forward planning method can reduce dose inhomogeneity and exposure of OARs. The efficacy of the FiF approach needs to be compared against IMRT in future studies.

The ideal postmastectomy irradiation technique remains an ongoing controversial issue. This is largely attributable to the inconsistency in planning among various institutions and literature. The variation in number, angle, and weightage of beams, inclusion of nodal volumes, along with anatomical variations, also impact on the dosimetry other than the technique utilized. This poses a major challenge in claiming the superiority of one technique over another. The decision of ideal technique needs to be individualized on a case-to-case basis, taking into account the risk factors predicting local recurrence impacting cause-specific survival against risk of manifesting long-term radiation-induced morbidity and mortality.

Conclusion

Although a clear advantage of one technique over another could not be established in the present study, but it certainly raises concerns about the possible increase in radiation-induced chronic sequelae with IMRT technique because of indispensable increase in low-dose volumes. The flaws of IMRT may be ameliorated by minimizing the number of beams and treatment in DIBH mode. But presently, in our opinion, the existing evidence is not strong enough to support growing practice of IMRT, and the benefit observed in our study could have been achieved by segmentation of two tangential fields into multiple subfields in 3DCRT plans. The clinical correlation also needs to be established with longer follow-up, demanding further research.

Conflict of Interest

None declared.

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