Dosimetric Comparison between Intensity-Modulated Radiation Therapy (IMRT) and 3D Conformal Radiotherapy for Adjuvant Left Breast Cancer

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Received: 23 May 2023
Accepted: 13 June 2023

Abstract:

Introduction: The aim of radiotherapy (Rth) is to provide optimal dose to the target with the least dose to surrounding risk structures. Intensity-modulated radiation therapy (IMRT) intends to improve the reach of optimal dose conformity to the target with the least risk structure dose. The aim of the study is to compare dose to the target and risk structures using (IMRT) and 3D conformal radiotherapy (3DCRT) for adjuvant left breast cancer.

Methods: This study included 20 localized unilateral breast cancer patients treated for adjuvant 3DCRT in the Aswan Cancer Centre. The treatment was planned for 3DCRT and then another plan for IMRT later on for the purpose of this dosimetric study. We compared both plans for target structure coverage, risk structure, and number of monitor units.

Results: PTV total V95% was significantly better for IMRT vs. 3DCRT (92.2%) vs. 88% (p = 0.025). The conformity index was also significantly superior for IMRT planning. The other parameters for PTV total coverage and homogeneity index showed no significant difference between both techniques.
IMRT insignificantly reduced the mean heart dose, 2.6 Gy for IMRT vs. 3.2 Gy for conformal (p = 0.368). It was also observed that the IMRT plans achieved a lower left lung dose than the conformal ones, i.e., 7.7 Gy vs. 7.9 Gy (p = 0.38). Contralateral breast mean and D5 doses were significantly lower in favour of 3DCRT vs IMRT (0.7 vs. 1.1 and 0.1 vs. 0.8; P values =0.01 and 0.043) respectively.

Conclusion: Overall, IMRT achieved superior dose parameters and marginally better risk structures sparing than 3D-CRT. However, contralateral breast mean and D5 doses were significantly better in favour of conformal planning.

Keywords: breast cancer, radiotherapy, left sided breast cancer, dosimetry

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Introduction:

Breast cancer is a major health problem worldwide and leading death cause in women in both developing and developed countries. [1]. Localized breast cancer is usually treated by surgery and combination of chemotherapy, hormonal, targeted therapy and radiotherapy which is personalized for each case [2]. Adjuvant radiotherapy is usually indicated in patients with T stage more than 5 cm and /or positive lymph

nodes which result in improvement in local recurrence and overall survival in some cases [3,4,5].

Our aim is give best tumor coverage with least dose to risk structures, so 3DCRT can do this work. However, this may be a challenge [6,7]. With introduction of IMRT, better coverage of target volumes and less dose to risk structures esp. heart and coronaries is suggested to be achieved by the new technique [8–10].

Van der Laan et al. study compared IMRT vs 3DCRT in left sided breast cancer and showed better coverage and less heart dose [11].

The aim of the study is to compare dose coverage to the target and risk structures using intensity modulated radiation therapy (IMRT) and 3D conformal radiotherapy for adjuvant left breast cancer.

Patients and Methods:

This study included 20 localized unilateral left breast cancer patients indicated per protocol; for adjuvant radiotherapy treated in the Aswan Cancer Centre, Egypt.

Patients were older than 18 years. All patients underwent surgery and received adjuvant systematic treatment per center protocol. CT images for simulation were taken from neck to end of lung bases

For the same patient two plans were done 3DCRT and IMRT with the aim of 95%coverage to PTV by 95% of intended dose.

Homogeneity index and Conformity index were defined according to the International Commission on Radiation Units and Measurements (ICRU) Report 83 [13] For the critical structures, heart mean dose and other parameters as V30, V5, and V10 of the heart. Regarding lung V20, V5, and V10 and the mean dose of the ipsilateral lung, and the mean dose of the contralateral breast were calculated. The monitor units and treatment delivery times were counted.

All data were entered into and analyzed using Microsoft Excel 2007 and the Statistical Package for Social Sciences (SPSS) version 20.0 (IBM Corp., Armonk, New York, USA) for statistical analysis. Quantitative data were analyzed using the t-test for two independent means. The two-tailed p-value reports were statistically significant at an alpha level of 0.05.

Results:

Target coverage

PTV total V95% is 88.8% 1.1% with 3D conformal and 92.2% 1.1% with IMRT (p = 0.025). Motor units used were significantly higher for IMRT. All coverage parameters are shown in Table 1.

Normal tissue sparing

IMRT slightly reduced the mean dose to the heart, 2.6 Gy for IMRT vs. 3.2 Gy for conformal (p = 0.368). (Table 2). It was also found that the IMRT plans achieved a lower mean dose to the left lung than the conformal ones, i.e., 7.7 Gy vs. 7.9 Gy (p = 0.38). Moreover, the values of left lung V10, V20, and V30 were 23.7.0%, 20.7%, and 10.4 for conformal, and 21.8, 12.4, and 6.9 for IMRT, respectively. The mean dose to the contralateral breast was 16.9 and 15.7 Gy, respectively (p = 0.5).

The dose rate for 3D conformal was 325 MU/min, and the maximum dose rate for IMRT was 1013 MU/min (0.02) (Table 2).

Table 1: Comparison of the dose coverage between IMRT and 3DCRT

	Conformal (mean±SD)	IMRT (mean±SD)	P value
PTV total V95 (%)	88.8±4.7	92.2±1.4	0.025
PTV total max (Gy)	43.18±0.43	43.2±0.38	0.74
PTV total min (Gy)	19±9.5	24.2±6	0.08
PTV total mean (Gy)	39.7±0.4	40.2±0.27	0.12
Conformity index (CI)	0.69±0.12	0.85±0.13	0.052
Homogeneity index (HI)	0.17±0.09	0.14±0.08	0.15
MU	325±10	1013±145	.0001

PTV total: planning target volume; IMRT: intensity modulated radiotherapy

Table 2: Comparison parameters of normal tissue between conformal and IMRT

	Conformal (mean±SD)	IMRT (mean±SD)	P value
V10 lung cm^3	23.7±5.6	21.8±5.3	0.4
V20 lung cm^3	20.7±13	12.4±3	0.15
V30 lung cm^3	10.4±4.1	6.9±3.1	0.34
Lung mean dose Gy	7.9±1.7	7.7±1.8	0.38
Heart Max dose Gy	38.7±2	38.4±2.8	0.87
Heart mean dose Gy	3.2±0.5	2.6±0.5	0.368
D33 heart Gy	2.5±0.4	1.7±0.2	0.69
V25 heart cm^3	1.8±1	1.4±1	0.68
V10 heart cm^3	4.7±2.2	5.3±1.7	0.117
Contralateral breast max dose Gy	7.6±5.6	20±12	0.015
Contralateral breast mean dose Gy	0.7±0.1	1.1±0.35	0.02
Contralateral breast D5 Gy	1.9±0.4	2.5±1	0.03
Contralateral breast V5 cm^3	0.1±0.13	0.8±0.6	0.012
Coronary artery max dose Gy	39.2±6	36.3±16	0.28
Coronary artery mean dose Gy	17.1±7.4	15.1±8	0.542
Coronary artery D5Gy	31.2±8.3	28.2±9.9	0.32
Coronary artery D2 Gy	33.2±7.3	30.7±8.2	0.43
Coronary artery D25 Gy	23.7±10	22±12	0.43

IMRT = intensity-modulated radiotherapy; SD = standard deviation.

Discussion:

Theoretically, IMRT can achieve better tumor coverage and less dose to risk structures but this needs clinical validation. In our study, we reported a dosimetric comparison between the two techniques in 20 cases of left-sided breast cancer.

In our study, the 3D-CRT and IMRT plans showed better PTV V95% coverage in favor of IMRT planning, and the MU used was statistically higher for the IMRT group, which is consistent with many other studies [24, 25; 28–33].

Moreover, the conformity index was statistically significant for IMRT planning, and this is consistent with most of the previous studies [25, 28–31].

However, a study conducted by Rastogi K. et al. showed no difference between the 2 techniques regarding PTV V95% coverage.

Other parameters, such as PTV max (Gy), PTV min (Gy), PTV mean (Gy), and homogeneity index (HI), were not statistically different between the 2 groups. In similar studies, these parameters showed contradictory results [24, 25; 28–33].

Mean lung dose and V20 less than 30% is good predictors for clinical pneumonitis in breast cancer and non small cell lung cancer cases [16-19].

In our study, there was no difference regarding lung dose constraints between IMRT and 3DCRT. This is consistent with several studies that showed that IMRT significantly reduced the ipsilateral lung dose and heart dose in 20 subsequent postmastectomy breast cancer patients. However, in low dose region constraints (lung V5, 10), 3DCRTH showed less dose received as compared to IMRT. [24,25,28-31].

However, a study done by Baycan et al. showed no difference between the two techniques regarding lung dose constraints.

In breast cancer patients, heart dose is crucial as large number of patients receiving cadiotoxic drugs as anthracycline and trastuzumab especially for left sided patients [20-23].

In our study, the dose to the heart in the IMRT plan and the 3D-CRT plan was not statistically significant, and this was consistent with other studies that showed conflicting results [24, 25; 28–31].

The dose to the contralateral breast is another important problem we should consider especially for younger age. Older studies showed that mean dose to the contralateral breast was 3.2 Gy with RapidArc [26, 27].

In our study, contralateral breast mean and D5 doses were significantly better in favor of conformal planning; however, other similar studies showed conflicting data [24, 25; 28–31].

The limitation of this study is the relative small number of patients included; it is also better for this study to include a systematic review of all previous similar studies.

Conclusion:

Overall, our results showed that IMRT achieved better target coverage and marginally better normal tissue sparing than 3D-CRT. However, contralateral breast mean and D5 doses were significantly better in favour of conformal planning.

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