



Dosimetric Comparison of Helical Tomotherapy and VMAT For Comprehensive Chest Wall and Nodal Irradiation in Left-Sided Breast Cancer Patients

İD Ayşenur ELMALI,¹ İD Recep BOZCA,² İD Yemliha DÖLEK,² İD Ozan Cem GÜLER,² İD Birhan DEMİRHAN,³
İD Cem ÖNAL²

¹Department of Radiation Oncology, Başkent University Faculty of Medicine, Ankara-Türkiye

²Department of Radiation Oncology, Başkent University Faculty of Medicine, Adana Dr. Turgut Noyan Research and Treatment Center, Adana-Türkiye

³Department of Radiation Oncology, İskenderun Gelişim Hospital, Hatay-Türkiye

OBJECTIVE

We analyzed the dosimetric performance of Helical Tomotherapy (HT) and Volumetric Modulated Arc Therapy (VMAT) for postmastectomy chest wall irradiation (CWI) in patients with left-sided breast cancer, with a particular focus on target volume coverage, organ-at-risk (OAR) sparing, and low-dose exposure to surrounding normal tissues.

METHODS

Twenty patients with left-sided breast cancer who received postmastectomy CWI and regional nodal irradiation were retrospectively evaluated. For each patient, HT and VMAT treatment plans were generated. Dosimetric parameters assessed included planning target volume (PTV) coverage, conformity index (CI), homogeneity index (HI), and dose-volume metrics for OARs. Low-dose exposure to normal tissues was quantified using V_{10Gy} and V_{25Gy} . Statistical comparisons were performed using the Mann-Whitney U test.

RESULTS

Both techniques achieved clinically acceptable PTV coverage and comparable HI. VMAT plans demonstrated significantly better CI than HT (CI: 0.79 ± 0.04 vs. 0.64 ± 0.03 ; $p < 0.001$). VMAT was associated with significantly lower high-dose exposure to the ipsilateral lung (V_{20Gy} and V_{30Gy}) and heart, and reduced mean dose to the contralateral breast. The VMAT plans also resulted in significantly lower low-dose body volumes (V_{10Gy} and V_{25Gy}) compared to HT. Additionally, VMAT required fewer monitor units and shorter treatment times.

CONCLUSION

Both HT and VMAT are effective for chest wall irradiation in left-sided breast cancer; however, VMAT provides superior dose conformity, improved OAR sparing, and reduced low-dose exposure. These findings support the preferential use of VMAT in clinical settings where minimization of normal tissue exposure and treatment efficiency are priorities.

Keywords: Breast cancer; chest wall irradiation; dosimetric comparison; helical tomotherapy; low-dose exposure; volumetric modulated arc therapy.

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Dr. Cem ÖNAL

Başkent Üniversitesi Tıp Fakültesi,

Radyasyon Onkolojisi Anabilim Dalı,

Adana Dr. Turgut Noyan Araştırma ve Tedavi Merkezi,

Adana-Türkiye

E-mail: hcemonal@hotmail.com

INTRODUCTION

Postmastectomy chest wall irradiation (CWI), often delivered in conjunction with regional lymph node radiotherapy (RT), constitutes a critical component of adjuvant treatment for patients with high-risk breast cancer. Robust clinical evidence supports its role in enhancing locoregional control and improving overall survival outcomes.[1,2] From a radiophysics standpoint, the primary objective of CWI is to ensure adequate dose coverage of complex target volumes while minimizing radiation exposure to surrounding healthy tissues—a task that becomes particularly challenging in left-sided breast cancer due to the proximity of the heart and lungs and the intricate geometry of regional lymphatic drainage pathways.[3–5]

A variety of RT techniques are employed for chest wall and nodal irradiation, including three-dimensional conformal radiotherapy (3DCRT), field-in-field (FIF) methods, and more advanced techniques such as intensity-modulated radiotherapy (IMRT) and volumetric modulated arc therapy (VMAT).[6–8] While conventional tangential-based 3DCRT reduces the dose to adjacent organs at risk (OARs), it is often associated with dose heterogeneity and the presence of high-dose hotspots, which may compromise target coverage and increase toxicity risk.[9,10] In contrast, IMRT and VMAT allow for enhanced dose conformity and homogeneity through inverse planning algorithms and dynamic modulation of beam fluence, thereby facilitating more effective sparing of OARs.

However, one trade-off associated with these advanced techniques is an increase in the volume of normal tissue exposed to low-dose radiation, particularly in contralateral thoracic structures. This “low-dose bath” raises concerns about the potential for late effects, including radiation-induced secondary malignancies, especially in younger patients.[11,12] Among these modalities, VMAT has demonstrated superior dosimetric performance compared to IMRT in several studies, offering more efficient dose delivery, improved target coverage, and reduced treatment times through continuous gantry rotation and dose rate modulation.[10,13,14]

Helical Tomotherapy (HT) is a form of IMRT that integrates CT-based image guidance with rotational beam delivery, enabling highly conformal treatment of anatomically complex volumes such as the chest wall and axillary-supraclavicular nodal basins. Its capacity for fine spatial resolution and steep dose gradients makes HT particularly well-suited for left-sided breast

cancer, where cardiac and pulmonary sparing are critical considerations.[15,16] Despite these theoretical advantages, direct dosimetric comparisons between HT and VMAT in the postmastectomy setting remain limited, particularly when regional lymphatics are included in the target volume.[17]

This study aims to perform a comprehensive dosimetric evaluation of HT versus VMAT for CWI in patients with left-sided breast cancer, with a particular emphasis on planning target volume (PTV) coverage, OAR sparing, and low-dose exposure metrics such as total body $V_{10\text{Gy}}$ and $V_{25\text{Gy}}$. By leveraging contemporary treatment planning systems and clinically relevant dose constraints, the analysis seeks to inform evidence-based selection of RT modalities for complex postmastectomy treatment scenarios.

MATERIALS AND METHODS

Ethical approval was not required for this study; however, all procedures were conducted in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Patient Selection

This retrospective dosimetric study included 20 consecutive patients with histologically confirmed left-sided breast cancer who underwent postmastectomy CWI with regional nodal coverage. Inclusion criteria were: (1) Completion of RT to the chest wall and regional lymphatics, and (2) availability of complete CT simulation and treatment planning data. Patients were excluded if they had a prior history of thoracic RT, bilateral breast cancer, recurrent disease, or incomplete imaging datasets.

All patients were treated at a single institution using uniform simulation, contouring, and planning protocols. No respiratory motion management techniques (e.g., deep inspiration breath-hold) were employed; all simulations were performed under free-breathing conditions to ensure consistency across the cohort. The study was approved by the institutional review board, and informed consent was waived due to the anonymized and retrospective nature of the analysis.

The median age of the cohort was 34 years (range: 26–52 Years). At diagnosis, 13 patients (65%) presented with T3N1 disease and 7 (35%) with T2N1 disease.

Target Volume and Organs-at-Risk Delineation

Simulation CT scans were acquired in the supine position using a breast board angled at 10°–15°, with both arms elevated. CT images were obtained at 2.5 mm slice thickness under free-breathing conditions. Clinical target volumes (CTVs) were delineated according to Radiation Therapy Oncology Group (RTOG) guidelines and included the left chest wall and regional lymphatics (axillary levels I–III and supraclavicular nodes).

The PTV was generated by applying a 5 mm isotropic margin around the CTV, excluding a 2–3 mm subcutaneous layer to minimize skin toxicity. The heart and lungs were excluded from the PTV. The OARs included the ipsilateral and contralateral lungs, heart, contralateral breast, esophagus, spinal cord, and liver. The heart was contoured from the level of the pulmonary trunk to the diaphragmatic surface, excluding pericardial fat. All contours were created by a single radiation oncologist and reviewed independently by a second specialist to ensure consistency. Normal tissue outside the PTV was defined as the volume between the body contour and the PTV and was used to assess low-dose exposure.

Treatment Planning

For each patient, two treatment plans—one using HT and one using VMAT—were generated on the same CT dataset. The prescribed dose was 50.4 Gy in 28 fractions (1.8 Gy/fraction) for both techniques, ensuring that at least 95% of the PTV received the prescribed dose. No tissue-equivalent bolus or virtual bolus was used in either plan.

VMAT plans were created using the Monaco treatment planning system (version 5.51.10, Elekta, UK) employing the Monte Carlo dose calculation algorithm. Each plan consisted of two partial arcs with gantry angles ranging from 300° to 180° in both clockwise and counterclockwise rotations. A fixed collimator angle of 15° was used to minimize interleaf leakage. Plans were intended for delivery on an Elekta Versa HD linear accelerator using 6 MV photon beams.

HT plans were generated using the TomoHDA system (Accuray Inc., Sunnyvale, CA, USA) with a helical fan-beam IMRT approach. Planning parameters included a field width of 2.5 cm, a pitch of 0.287, and a modulation factor of 2.5. Dose calculation was performed using a 3 mm grid resolution on a 256×256 axial matrix. Directional beam blocking was applied to limit dose to the contralateral breast, lateral hemibody, and posterior ipsilateral side.

All treatment plans were prepared by experienced dosimetrists and independently reviewed by a senior

physicist and radiation oncologist to ensure uniform quality across the cohort.

Dose constraints were applied to minimize OAR exposure without compromising PTV coverage. The volume of the heart receiving >30 Gy was restricted to <10%, and the ipsilateral lung volume receiving >20 Gy was limited to <20%. Mean dose constraints were set at <5 Gy for the contralateral breast and lung. The spinal cord dose was limited to ≤30 Gy.

Plan Evaluation

Plan evaluation was performed using cumulative dose-volume histogram (DVH) metrics for both the planning target volume (PTV) and organs at risk (OARs). For the PTV, key parameters included:

- D_2 and D_{98} : Representing the doses received by the most irradiated 2% and the least irradiated 98% of the target volume, respectively—used as surrogates for maximum and minimum dose.
- V_{95} and V_{107} : Defined as the percentage of the PTV receiving at least 95% and 107% of the prescribed dose, respectively.

The Conformity Index (CI) was calculated using the following formula:

$$CI = \frac{VT_{ref}}{TV} \times \frac{VT_{ref}}{V_{ref}},$$

where VT_{ref} is the target volume covered by the isodose, TV is the total target volume, and V_{ref} is the volume covered by 95% of the isodose.[18] The CI ranges from 0 to 1, with a value closer to 1 indicating better dose conformity to the PTV.

The HI was calculated as follows:

$$HI = \frac{D_2 - D_{98}}{D_{50}},$$

where D_2 and D_{98} were used as surrogates for maximum and minimum doses.[19] A higher HI value indicates greater non-uniformity in dose distribution.

For OARs, dosimetric evaluation included standard volume- and dose-based parameters. For the ipsilateral lung, V_{5Gy} , V_{20Gy} , V_{30Gy} , and mean dose (D_{mean}) were assessed. Heart exposure was quantified using V_{5Gy} , V_{10Gy} , V_{20Gy} , V_{30Gy} , and D_{mean} . For the contralateral breast and lung, V_{5Gy} and D_{mean} were evaluated. Maximum and mean doses were recorded for the esophagus, while only the maximum dose was analyzed for the spinal cord. Liver exposure was assessed using V_{20Gy} and D_{mean} . Additionally, to quantify low-dose radiation spread to non-target tissues, the total body volumes receiving at least 10 Gy (V_{10Gy}) and 25 Gy (V_{25Gy}) were measured.

Statistical Analysis

All statistical analyses were performed using SPSS software (version 25.0; IBM Corp., Armonk, NY, USA). Descriptive statistics included means, medians, standard deviations, and ranges. DVH metrics (Dn and Vn) were calculated for both PTV and OARs, where Vn denotes the percentage of a volume receiving at least n Gy, and Dn the dose received by n% of the volume. The Shapiro–Wilk test was applied to assess the normality of data distribution. As most variables did not follow a normal distribution, the Mann–Whitney U test was used to compare dosimetric outcomes between VMAT and HT. No corrections were made for multiple comparisons due to the exploratory nature of the analysis. A p-value <0.05 was considered statistically significant.

RESULTS

Target-Volume Doses

The median PTV volume was 680.6 cm³ (range: 412.4–985.7 cm³). All HT and VMAT plans achieved the planning objective of delivering at least 95% of the prescribed dose to ≥95% of the PTV.

There were no significant differences between the two techniques in terms of D₂, D₉₈, V₉₅, or V₁₀₇, with both demonstrating comparable HI. However, the CI was significantly higher in the VMAT plans compared to HT (0.79±0.04 vs. 0.64±0.03; p<0.001), indicating

Table 1 Target volume doses according to helical tomotherapy (HT) and volumetric-modulated arc therapy (VMAT) plans

Parameters	HT plan (mean±SD)	VMAT plan (mean±SD)	p
V ₁₀₇ (%)	0.70±0.72	0.73±0.50	0.46
V ₉₅ (%)	98.33±0.79	98.23±0.95	0.69
D ₂ (Gy)	53.38±0.42	53.63±0.16	0.03
D ₉₈ (Gy)	48.22±0.82	48.14±0.89	0.52
D _{mean} (Gy)	51.84±0.42	51.80±0.25	0.42
CI	0.64±0.03	0.79±0.04	<0.001
HI	0.10±0.02	0.11±0.02	0.30

SD: Standard deviation; V: Volume; D: Dose; Gy: Gray; CI: Conformity index; HI: Homogeneity index.

better dose conformity with VMAT. Although the D₂ was slightly higher with VMAT (53.63 Gy vs. 53.38 Gy), this 0.25 Gy difference was not considered clinically meaningful (Table 1; Fig. 1).

Organs at Risk Doses

All OAR dose constraint criteria were met; however, there were significant differences in some parameters between the HT and VMAT plans. Specifically, the ipsilateral lung V_{20Gy}, V_{30Gy}, and mean lung doses were significantly lower in the VMAT plan compared to the HT plan (Fig. 2a). There was no significant difference in the lung V_{5Gy} between the two plans. Additionally, the high dose volumes (V_{20Gy} and V_{30Gy}) for the heart

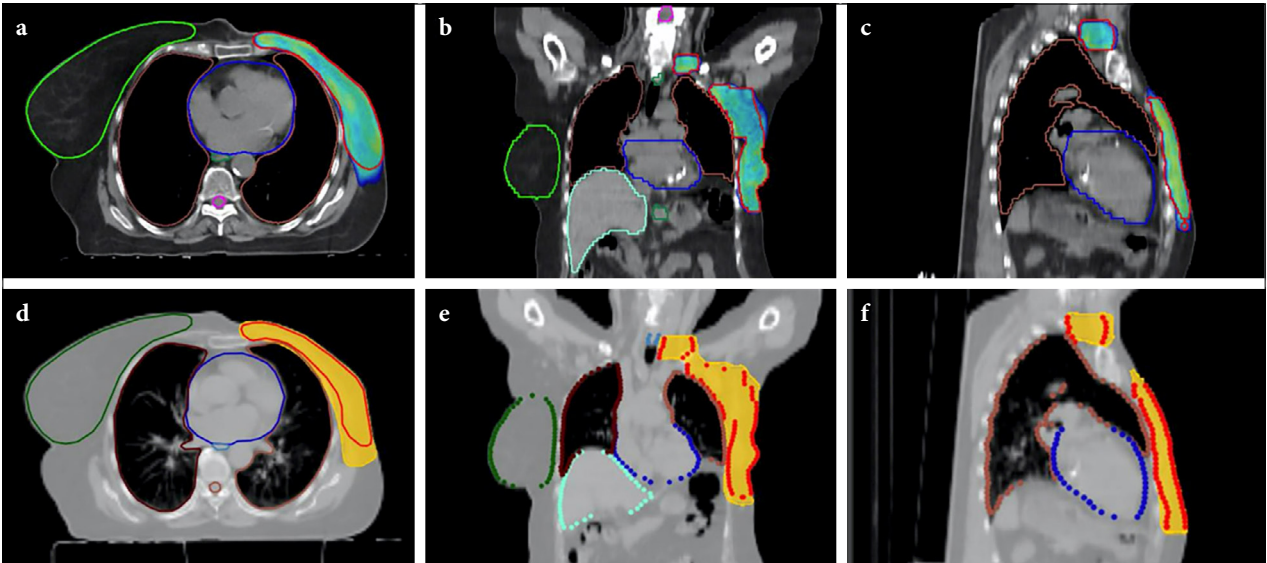


Fig. 1. Dose distribution illustrating the 90% prescribed dose for chest wall and lymphatic areas in axial, coronal, and sagittal sections for (a-c) Volumetric-Modulated Arc Therapy (VMAT) and (d-f) Helical Tomotherapy (HT) plans. The 90% isodose volume is shown as a green area for VMAT and an orange area for HT.

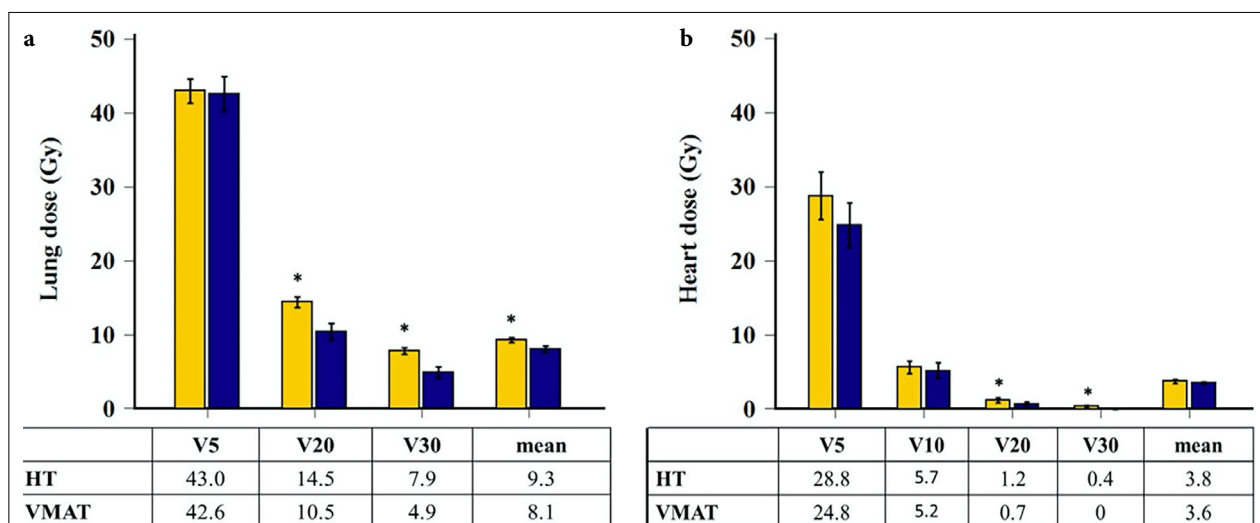


Fig. 2. Box-and-whisker plots showing (a) doses to the ipsilateral lung and (b) doses to the heart, including dose volume parameters and mean lung doses for HT (yellow bars) and VMAT (blue bars) plans.

were significantly lower in the VMAT plan than in the HT plan; however, the absolute differences (0.5% and 0.4%, respectively) are minimal and may not be clinically significant (Fig. 2b). However, no significant differences were observed between the two plans for heart low dose volumes ($V_{5\text{Gy}}$ and $V_{10\text{Gy}}$) and D_{mean} .

The contralateral breast $V_{5\text{Gy}}$ and D_{mean} were significantly lower in the VMAT plan compared to the HT plan (Table 2). Although no significant difference in contralateral lung $V_{5\text{Gy}}$ was observed between the two plans, the mean lung dose was significantly higher in the VMAT plan than in the HT plan.

There were no significant differences in spinal cord and liver doses between the two plans. However, the maximum and mean doses to the esophagus were significantly higher in the VMAT plan compared to the HT plan.

Low-Dose Volumes and Treatment Efficiency

The body low dose volumes were significantly higher in the HT plan compared to the VMAT plan (Fig. 3). Specifically, the body $V_{25\text{Gy}}$ and $V_{10\text{Gy}}$ were significantly greater in the HT plan, with values of 2534 ± 462 cc versus 1976 ± 383 cc ($p=0.001$) and 4709 ± 838 cc versus 3578 ± 716 cc ($p=0.001$), respectively (Fig. 4).

The monitor unit (MU) delivered was significantly lower in the VMAT plan compared to the HT plan (1821 ± 166 vs. 6189 ± 499 ; $p<0.001$). Similarly, the treatment time was significantly shorter for the VMAT plan than for the HT plan (7.1 ± 0.6 min vs. 6.0 ± 0.6 min; $p<0.001$).

DISCUSSION

This study presents a detailed dosimetric comparison between HT and VMAT for postmastectomy CWI in patients with left-sided breast cancer. Both modalities provided clinically acceptable target volume coverage and met dose constraints for OARs. However, VMAT demonstrated superior dose conformity, lower expo-

Table 2 Organs at risk doses according to helical tomotherapy (HT) and volumetric-modulated arc therapy (VMAT) plans

Parameters	HT plan (mean±SD)	VMAT plan (mean±SD)	p
Contralateral lung			
$V_{5\text{Gy}}$ (%)	3.20±1.23	3.21±0.90	0.88
D_{mean} (Gy)	2.02±0.29	2.70±0.24	<0.001
Contralateral breast			
$V_{5\text{Gy}}$ (%)	4.05±0.99	2.52±1.26	<0.001
D_{mean} (Gy)	2.69±0.23	2.08±0.27	<0.001
Spinal cord			
D_{max} (Gy)	17.50±3.93	14.92±0.56	0.8
Esophagus			
D_{max} (Gy)	34.91±7.43	40.18±4.76	0.01
D_{mean} (Gy)	5.42±1.63	6.53±1.32	0.02
Liver			
$V_{20\text{Gy}}$ (%)	0	0	1.00
D_{mean} (Gy)	1.67±0.71	1.69±0.77	0.98

SD: Standard deviation; V: Volume; D: Dose; Gy: Gray; CI: Conformity index; HI: Homogeneity index.

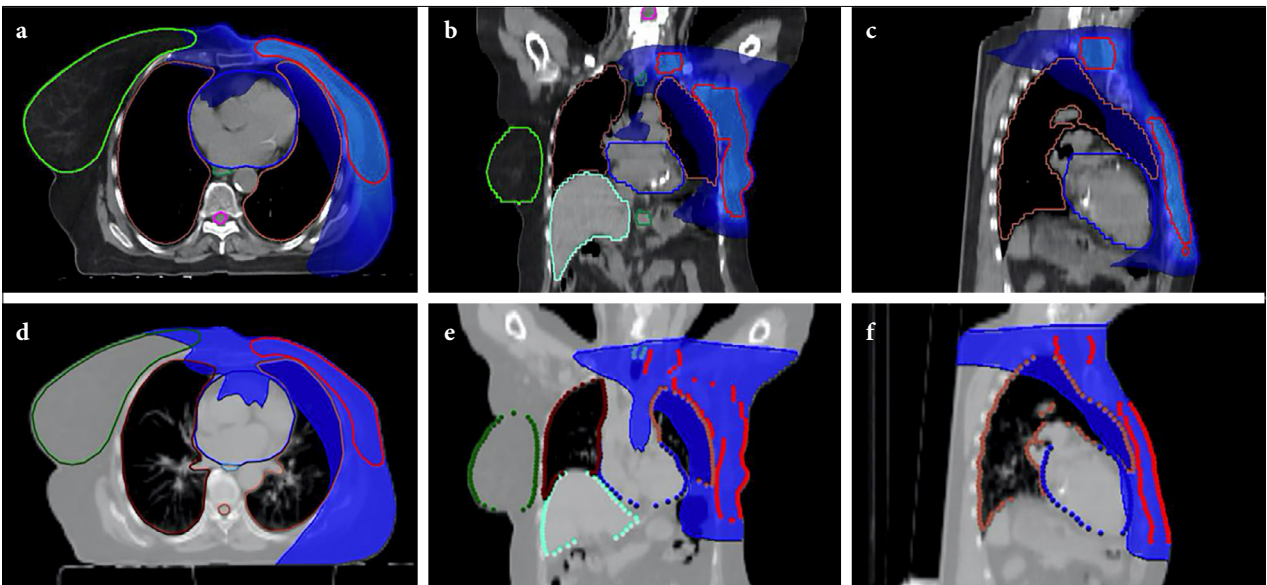


Fig. 3. Dose distribution demonstrating the volume receiving 5 Gy (blue area) in axial, coronal, and sagittal sections for (a-c) VMAT and (d-f) HT plans.

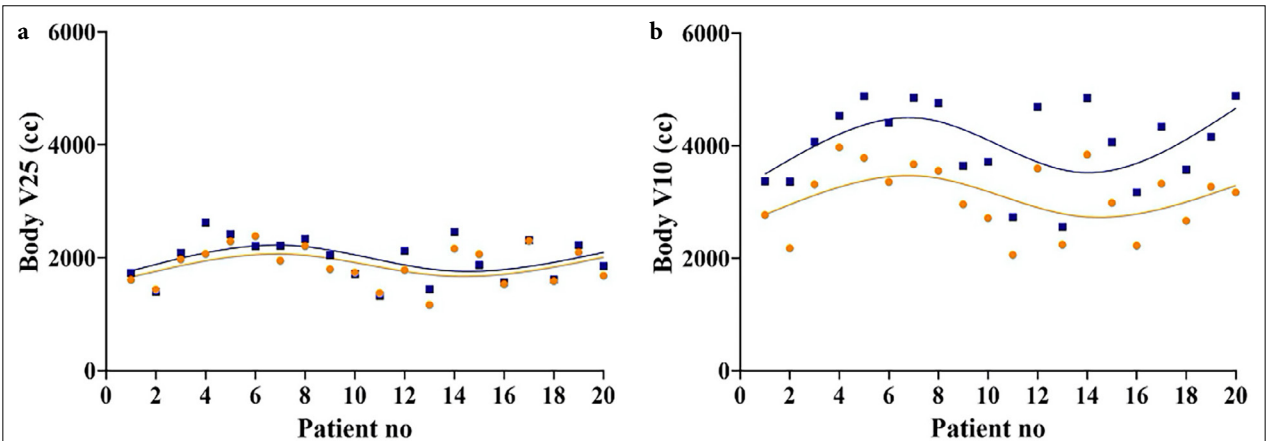


Fig. 4. Volumes receiving (a) 25 Gy and (b) 10 Gy for each patient. The HT plan is represented by blue squares, and the VMAT plan is represented by orange circles.

sure to critical structures, and enhanced treatment efficiency compared to HT. These findings highlight VMAT's ability to achieve precise dose shaping, even in anatomically complex regions such as the chest wall and regional lymphatics. These dosimetric advantages may translate into improved acute and late toxicity outcomes, although further clinical validation is needed.

Postmastectomy CWI poses distinct planning challenges, particularly due to the thin, curved chest wall and its close proximity to critical organs such as the heart and lungs. Traditional 3DRT techniques and FIF tangents often result in suboptimal

dose uniformity and coverage, prompting a shift toward advanced techniques like IMRT, VMAT, and HT.[8,10,13,14,20] Although HT has been traditionally favored for its uniform dose delivery over extended volumes, the lower CI observed in this study may reflect limitations related to beam-blocking strategies, target complexity, and specific planning parameters (pitch and modulation factor).[21–23] Comparative findings from previous studies are summarized in Table 3. Additionally, variation in contouring practices and CI calculation methods across studies may contribute to these discrepancies.

Table 3 Studies comparing helical tomotherapy (HT) and volumetric modulated arc therapy (VMAT) in postmastectomy radiotherapy for left-sided breast cancer

Study	Participants	Treatment	Target coverage	Heart	Ipsilateral lung	Contralateral breast	Total body dose	Study conclusion
Haciislamoglu et al.[23]	15 patients	WBI 50 Gy in 25 fractions	HT better in CI and HI	HT superior in $D_{mean} V_{5Gy}$	HT better in $D_{mean} V_{20Gy}$	VMAT better in V_{3Gy}, V_{5Gy}	VMAT is superior for V_{3Gy}, V_{5Gy}	HT reduces high doses and increases low doses to OARs
Nobnop et al.[21]	30 patients	CWI + RNI 50 Gy in 25 fractions	HT better in V95, HI, and CI	VMAT better in $D_{mean} V_{10Gy}, V_{20Gy}$	HT better in V_{20Gy}	VMAT better in V_{5Gy}, D_2	N/A	HT provides better homogeneity and conformity; VMAT spares the heart better
Hou et al.[22]	108 patients	CWI or WBI+RNI 45–50.4 Gy in 25–28 fractions	N/A	VMAT better in $D_{mean} V_{5Gy}, V_{10Gy}, V_{15Gy}, V_{20Gy}$	VMAT better in $V_{5Gy}, V_{10Gy}, V_{20Gy}$	VMAT better in D_{mean}	N/A	VMAT reduces mean and low-dose exposure to OARs; recommended for left-sided breast RT
Present study	20 patients	CWI + RNI 50.4 Gy in 28 fractions	HT has lower D_{2cc}	VMAT better in V_{20Gy}, V_{30Gy}	VMAT better in $D_{mean}, V_{20Gy}, V_{30Gy}$	VMAT better in D_{max}, V_{5Gy} ; HT superior in D_{mean}	VMAT better in V_{10Gy}, V_{25Gy}	VMAT superior in most areas; HT better in specific metrics

WBI: Whole breast irradiation; CWI: Chest wall irradiation; RNI: Regional nodal irradiation; HT: Helical tomotherapy; VMAT: Volumetric-modulated arc therapy; OAR: Organ at risk.

Radiation pneumonitis remains a significant risk following postmastectomy CWI, and strict sparing of the ipsilateral lung is essential to mitigate this complication. Established dose–volume parameters—particularly V_{5Gy} , V_{10Gy} and V_{20Gy} —serve as key predictors of pneumonitis, though debate persists regarding which metric is most prognostic.[24,25] Consistent with prior series, our results showed that VMAT significantly reduced ipsilateral lung V_{20Gy} , V_{30Gy} and mean dose compared to HT.[24,25] These reductions, though modest, are clinically meaningful given their association with lower pulmonary toxicity. The absence of a significant difference in V_{5Gy} suggests that both modalities are comparable in terms of low-dose lung exposure, a factor particularly relevant for secondary malignancy risk.

Cardiac toxicity remains a prominent concern in left-sided breast cancer radiotherapy. Prior research has established a dose–response relationship between mean heart dose and the risk of major cardiac events, with Darby et al.[3] reporting a 7.4% increase in ischemic events per Gy. While no absolute threshold has been universally established, most guidelines advocate for keeping the mean heart dose below 5–7 Gy to reduce cardiovascular risk.[26,27] Comparative studies evaluating cardiac exposure across different planning techniques have yielded mixed results. For instance, Goksel et al.[28] observed higher V_{5Gy} values with VMAT relative to HT, whereas Phurailatpam et al.[29] reported no meaningful difference between the two in bilateral breast treatment. Conversely, Hou et al.[22] demonstrated superior cardiac sparing with VMAT, citing significantly lower mean heart dose (3.82 Gy vs. 5.13 Gy, $p<0.001$) and reduced volumes receiving 5–20 Gy. Xie et al.,[17] similarly reported lower V_{5Gy} and V_{10Gy} values with VMAT, while maintaining comparable V_{30Gy} values. In our analysis, both HT and VMAT achieved median mean heart doses below 5 Gy, consistent with established dose constraints. However, VMAT was associated with a significant reduction in high-dose cardiac volumes (V_{20Gy} and V_{30Gy}), which may hold particular relevance for mitigating long-term cardiac morbidity. No significant differences were observed in lower-dose cardiac parameters, indicating that both techniques are capable of providing acceptable baseline cardiac sparing when appropriately planned. It is important to acknowledge that cardiac dose metrics are influenced by multiple variables, including target volume complexity, contouring variability, beam geometry, and institutional planning protocols.

The extent of low-dose radiation spillage to non-target tissues is increasingly recognized as a factor in the

development of radiation-induced secondary malignancies.[30,31] Additionally, factors such as higher MU requirements and prolonged treatment times may further contribute to this risk. Our analysis demonstrated that HT was associated with significantly higher total body V_{10Gy} and V_{25Gy} values compared to VMAT, consistent with prior reports suggesting that rotational delivery techniques may increase integral dose despite offering improved dose homogeneity. Given the relatively young median age of the study cohort and the extended life expectancy of breast cancer survivors, minimizing low-dose radiation exposure is particularly important—especially for individuals with BRCA mutations or other genetic susceptibilities. The increased exposure of healthy tissue to sub-therapeutic dose levels with HT may contribute to a higher long-term risk of secondary malignancies and other late effects. These considerations underscore the need for a patient-specific, risk-adapted approach when selecting the optimal radiotherapy technique. By incorporating underreported metrics such as V_{10Gy} and V_{25Gy} , this study highlights a clinically relevant aspect of radiation exposure that warrants careful attention in treatment planning for breast cancer patients.

VMAT was associated with a substantial reduction in MU and beam-on time relative to HT. This may contribute to improved patient throughput and reduced intrafraction motion. Shorter treatment times are also advantageous in clinical settings where patient comfort and immobilization stability are essential for precision delivery.

Although this study focused on dosimetric endpoints, the observed advantages with VMAT are likely to translate into clinically relevant improvements in toxicity profiles. Lower heart and lung doses have been linked to decreased rates of major coronary events and radiation pneumonitis.[24,25] Moreover, reductions in low-dose volumes may mitigate long-term risks of second malignancies, especially in younger or genetically predisposed patients.[11,12]

This study has some limitations. First, clinical outcome data (e.g., toxicity, recurrence) and patient-reported measures were not available, preventing correlation of dosimetric parameters with real-world endpoints. Second, the absence of respiratory motion management techniques such as DIBH may have influenced heart and lung doses. While uniform use of free-breathing ensured internal consistency, DIBH is increasingly employed to further minimize cardiac exposure. Third, although the sample size is larger than most prior dosimetric comparisons, it remains limited and may not capture subtle differences. Finally,

HT planning involved fixed beam-blocking strategies, which may have restricted optimization flexibility and impacted dose conformity.

Despite these limitations, the study offers valuable insight into the comparative performance of two widely used advanced radiotherapy techniques for a complex clinical scenario. The inclusion of underreported dosimetric metrics such as V_{10Gy} and V_{25Gy} further enhances the clinical relevance of the analysis. However, treatment selection should remain individualized, considering patient anatomy, disease extent, and institutional expertise.

CONCLUSION

Both HT and VMAT are effective techniques for delivering postmastectomy CWI in patients with left-sided breast cancer, achieving adequate target coverage and compliance with OARs constraints. This dosimetric analysis revealed that VMAT outperforms HT in several critical areas, including superior dose conformity, enhanced high-dose sparing of the heart and ipsilateral lung, and significantly reduced low-dose exposure to surrounding normal tissues. VMAT also demonstrated greater treatment efficiency, with lower monitor unit requirements and shorter beam-on times. These findings support the preferential use of VMAT in clinical settings where minimizing normal tissue exposure and optimizing delivery efficiency are of high priority. Nonetheless, selection of the optimal RT technique should remain patient-specific, taking into account individual anatomical considerations, institutional resources, and the treating physician's expertise. Future prospective studies incorporating clinical outcomes, patient-reported toxicity, and the integration of advanced motion management strategies are warranted to validate these dosimetric advantages and optimize technique selection in the management of left-sided breast cancer.

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