Original Article

# Dosimetric comparison of left sided whole breast irradiation with Tangential wedge beam, electron boosted Tangential wedged beam and asymmetric technique

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## Abstract

**Background:** Irradiation of the adjacent critical structures is inevitable in breast cancer radiotherapy (RT). Our purpose is to assess the dose distribution across the breast tissue and adjacent organs with our institutional asymmetric technique for left-sided breast cancer compared to the standard tangential wedged beam (TWB) and electron-boosted TWB techniques. **Materials and Methods:** The three RT planning were created for 30 consecutive patients with a focus on proper coverage of the planning target volume (PTV). The irritated doses into the heart, ipsilateral lung, and left anterior descending artery (LAD) were evaluated. **Results:** No significant difference was found in the mean values of relative PTV irradiated to 47.5 Gy, PTV dose and the volume of PTV, and critical organs between the treatments. The mean dose (Dmean) irradiated to the heart and LAD was lowest with the electron-boosted TWB. The Dmean to the heart was comparable between the TWB and asymmetric RT techniques, while the Dmean to LAD was significantly reduced with asymmetric technique versus TWB. The heart volume receiving ≥25 Gy and the Dmean to the left lung were significantly decreased with the asymmetric technique compared with TWB. The mean relative lung volume irradiated to ≥20 Gy was comparable between all techniques. The mean central lung distance was also significantly increased from 18.03 ± 4.5 cm with asymmetric RT to 37.47 ± 5.6 cm with TWB and to 27.67 ± 3.8 cm with electron-boosted TWB techniques. **Conclusion:** The asymmetric technique is useful for patients with breast cancer on the left side, having acceptable PTV coverage and considerably reduced cardiopulmonary doses.

**Keywords:** Asymmetric therapy, breast cancer, tangential wedged beam

## Introduction

Surgery can be considered to treat breast cancer or any disorders in the breast or at distant sites in early stages, however, the disease deposits may remain undetected, leading to life-threatening recurrence if remain untreated. Recent studies have shown that radiotherapy (RT) for breast cancer in early stages can reduce the recurrence and mortality rates.[1] However, follow-up studies have shown that RT for left-sided breast has long-term side effects and can increase the risk of ischemic heart disease and pulmonary complications due to the inevitable heart and lung irradiation.[2-4]

Hence, new therapeutic techniques have been developed to obtain a uniform dose distribution in treatment volume and lower doses to adjacent organs at risk (OARs).[5,6] One of the

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treatment methods is tangential wedged beam (TWB) technique, in which two tangential photon beams are used to reduce the risk of irradiation to the heart and lung. To improve target dose homogeneity, wedges are often used.[7]

Modulated electron radiotherapy (MERT) has recently been applied to treat superficial targets including superficial tumors.[8] Electron beams with the ability to modulate the intensity or energy/intensity are available to confirm the target dose.[9]

Despite obvious advantages of intensity-modulated electrons/photons over TWB treatment,[9] more research should be done toward beam planning and delivery for electrons and photons. Using a combination of modulated electrons/photons is the ideal scenario, for example, the use of modulated electron radiotherapy (MERT) for tumor bed boosts and photons for the whole breast irradiation. MERT in combined with intensity-modulated radiation therapy (IMRT) technique is shown to have advantages over the TWB technique and can reduce the irradiated dose to the heart and the ipsilateral lung.[9]

RT techniques vary between institutions depending on their facilities. Considering the nonavailability of multileaf collimators, we designed planning using two usual tangential fields. In addition, medial and lateral beams were copied, but for decreasing the heart irradiation, the width of each beam was decreased by the asymmetric jaws as the asymmetric field.

Here, we performed a comparative dosimetric study to assess our institutional asymmetric method, electron-boosted TWB, and TWB in the treatment of left-sided breast cancer. We analyze the treatment plans with a focus on dose decrease and target dose homogeneity in the heart and lung.

# Materials and Methods

## Patients and computed tomography scanning

Thirty consecutive patients with cancer in their left-sided breast, who were sent to conduct adjuvant RT after breast-conserving surgery at the Shohadaye Haft-e Tir Hospital, were included between 2018 and 2019. The participants signed the informed consent. The study was approved by the Iran University of Medical Sciences.

To treat the patients, they posited in a supine position while their head turned slightly into the contralateral side and their arms elevated above the head. All the patients with left-sided breast cancer were selected to examine the influence of radiation therapy on the heart. In order to minimize the daily set-up errors and reproducing the daily situations, a custom-made immobilization device such as wing, vacuum, or T-board was utilized. Computed tomography (CT) simulation images with 5-mm thickness were obtained from the neck to the middle of the abdomen to insure the whole radiation area is included. Virtual reality-type techniques were used to design the treatment fields based on the CT-simulation data set. In this study, photon beams with 6 MV and 15 MV were used and obtained from an accelerator (Siemens Primus). To consider the respiratory motion effect in the photon treatment plans, up to 1 cm margin in the posterior direction was added to the planning target volume (PTV).

## Treatment planning details

1. TWBs
2. In the conventional tangential photon treatment, two physical wedges were used for two beams with aligned bottom edges and gantry angles of 300° and 235°
3. Two tangential photon beams were combined with an electron beam with enough energy. The electron beam was adjusted until an angle of 5°–10° was obtained laterally from the medial-lateral photon beams. The gantry angles of the two tangential photon beams were larger in comparison with its sizes in the conventional tangential fields. In addition, the length of electron and photon beams was equal. The electron field was 10 or 12 Mev, respectively. Medial electron field is also another common technique used to cover the IM nodes which is well tailored to shallow photon tangents
4. In our new planning technique, patients were treated with four beams: two tangential beams are used as the same as usual breast planning technique. In addition, medial and lateral beams were copied, and for sparing the heart from excessive radiation, the width of each copied beam was decreased as an asymmetric field. For uniform target dose distribution, we used 6-MV or 15-MV photon beams and 15° or 30° wedges. The angle of gantry for tangential asymmetric beams (medial) was more than of symmetric beams, but the angle of gantry for the other asymmetric beams (lateral) was less than symmetric beams. In addition, beam weighting in this technique in comparison to conventional technique was different.

For treating the PTV, specific objectives were established to treat 90% of the PTV with an ideal dose of 47.5 Gy but the minimum of 45 Gy and maximum hotspots of ≤107%. PTV should receive a mean dose (Dmean) within 100% of the prescribed dose and should not exceed 101.5%. The irradiated dose to OAR was held as low as possible so that the coverage criteria of PTV are not violated, even in the case of exceeding the dose limit of OAR. Treatment planning of radiation therapy was performed using the Isogray (version 4.1.3.23 L) treatment planning system. A dose of 50 Gy in 2.0 Gy per fraction should be delivered to the breast five times a week. Aiming to reduce the interobserver variability, one radiation oncologist did all the contouring. One medical physicist also designed the treatment plans.

## Statistical analysis

The irradiated doses to PTV and endangered organs were evaluated. The dose–volume histograms (DVHs) were used to obtain the mean and maximum doses as well as the volume size. The measurement of central lung distance (CLD) was done in a beam's eye view. Analysis of the differences was done in SPSS Statistics for Windows, version 21.0 (SPSS Inc., Chicago, Ill., USA) software using paired *t*-test. $P < 0.05$ was considered to be statistically significant.

## Results

The dosimetric plans for left-sided breast cancer were studied for the 30 patients using three different techniques.

### Volumes

All delineated volumes are shown in Table 1. There was not any significant difference in the mean volume of PTV between the three RT methods (708.19 ± 307.5 in TWB vs. 708.17 ± 307.5 in electron-boosted TWB vs. 685.27 ± 325.4 in asymmetric method, $P > 0.05$). In addition, for the delineated volumes of the heart, left anterior descending artery (LAD), and left lung, no significant difference was found.

### Treatment planning data for planning target volume

For all the three techniques of TWB (102 ± 1.44), electron-boosted TWB (103.57 ± 3.67), and asymmetric (101.6 ± 1.8), the mean PTV dose was comparable and close to 100% ($P > 0.05$). The mean respective PTV irradiated (V47.5) was 93.9%+-3.4% in TWB, 91.97%+-8.83%, and 92.43%+-5.1% in asymmetric RT plan ($P > 0.05$). Moreover, no significant difference was found in the V50 among all the three techniques. The V45 for asymmetric method was significantly less than the TWB method (97.18% ± 1.84% vs. 98.41% ± 1.34%, $P = 0.001$), while there was not any significant difference between the V45 of asymmetric and electron-boosted techniques (97.18% ± 1.84% vs. 97.50% ± 2.63%, $P = 0.51$) [Table 2]. Figures 1–4 show the corresponding DVHs. As shown in these figures, there is a tangible reduction in the dose irradiated to the heart, the ipsilateral lung, and the LAD artery.

### Cardiac doses

The mean irradiation dose to the LAD (37.04 ± 21.9) and heart (11 ± 5.5) was lowest in the electron-boosted TWB. The average dose to the heart was comparable between the TWB and asymmetric RT techniques (15.65 ± 5.43 vs. 23.2022.54, $P = 0.07$), while the Dmean of LAD was significantly reduced in asymmetric method compared with TWB (55.21 ± 18.7 vs. 60.55 ± 16.05, $P = 0.03$).

The mean relative volume of heart irradiated to 25 Gy was significantly decreased with asymmetric technique compared to the TWB (12.93% ± 5.7% vs. 14.82% ± 6.3%, $P = 0.004$). However, it was significantly larger for asymmetric technique in comparison to the electron-boosted TWB (12.93% ± 5.7% vs. 6.73% ± 5.8%, $P < 0.0001$). The mean irradiation dose to relative LAD volume (≥25 Gy) was comparable between all the three techniques (57.33% ± 18.77% in TWB, 45.9% ± 90.6% in electron-boosted TWB, and 57.14% ± 19.43% in asymmetric, $P > 0.05$) [Table 2].

**Table 1: The mean±standard deviation volume (cm$^3$) for target volumes and endangered organs**

| | TWB | Electron-boosted TWB | Asymmetric | *P* |
|---|---|---|---|---|
| PTV | 708.19±307.5 (314-1767) | 708.17±307.5 (314-1767) | 685.27±325.4 (115-1767) | >0.05 |
| Heart | 565.34±160.46 (17-913) | 586.63±123.26 (342-913) | 586.65±123.27 (342-913) | >0.05 |
| LAD coronary artery | 4.73±2.55 (1-12) | 4.71±2.57 (1-12) | 4.66±2.64 (1-12) | >0.05 |
| Ipsilateral lung | 1023.2±210.93 (570-1555) | 1025.77±212.34 (570-1555) | 1023.07±210.76 (570-1555) | >0.05 |

PTV: Planning target volume, TWB: Tangential wedged beam, LAD: Left anterior descending

**Table 2: Therapy planning data for the planning target volume and endangered organs**

| | TWB | Electron-boosted TWB | Asymmetric | *P* |
|---|---|---|---|---|
| PTV | | | | |
| Mean (%) | 102±1.44 | 103.57±3.67 | 101.6±1.8 | >0.05 |
| Maximum (%) | 109.64±2.8 | 117.5±5.96 | 108.96±2.84 | <0.0001# |
| V50 (%) | 69.84±11.97 | 67.87±16.72 | 69.33±12.33 | >0.05 |
| V47.5 (%) | 93.9±3.4 | 91.97±8.83 | 92.43±5.1 | >0.05 |
| V45 (%) | 98.41±1.34 | 97.50±2.63 | 97.18±1.84 | 0.001* |
| Heart | | | | |
| Mean (%) | 15.65±5.43 | 11±5.5 | 23.2022.54 | <0.0001# |
| Maximum (%) | 96.13±4.7 | 66.98±26.32 | 89.53±8.18 | <0.0001*,# |
| V25 (%) | 14.82±6.3 | 6.73±5.8 | 12.93±5.7 | 0.004*, <0.0001# |
| LAD coronary artery | | | | |
| Mean (%) | 60.55±16.05 | 37.04±21.9 | 55.21±18.7 | 0.3*, <0.0001# |
| Maximum (%) | 99.13±9.32 | 79.8±30.84 | 96.85±7.17 | 0.003# |
| V25 (%) | 57.33±18.77 | 45.9±90.6 | 57.14±19.43 | >0.05 |
| Ipsilateral lung | | | | |
| Mean (%) | 27.88±5.92 | 25.53±7.6 | 25.85±5.97 | 0.001* |
| Maximum (%) | 99.71±3.5 | 97.63±5.04 | 97.77±4.22 | 0.01* |
| V20 (%) | 27.32±6.3 | 24.4±8.3 | 26.28±6.5 | >0.05 |
| CLD of medial field (mm) | 37.47±5.6 | 27.67±3.8 | 18.03±4.5 | <0.0001*,# |

*Significant difference between asymmetric technique and TWB, #Significant difference between asymmetric technique and electron-boosted TWB. Data are represented as mean±SD. SD: Standard deviation, PTV: Planning target volume, TWB: Tangential wedged beam, LAD: Left anterior descending, CLD: Central lung distance

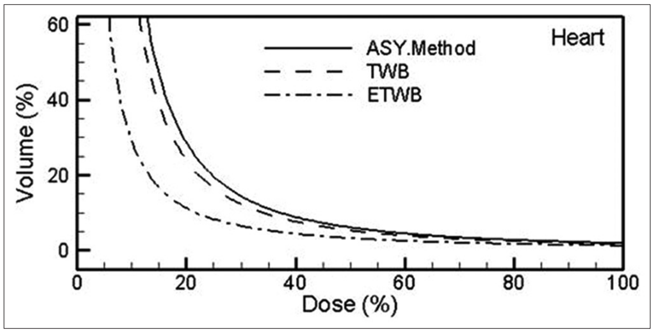


**Figure 1:** Histograms indicating the dose versus volume for the heart

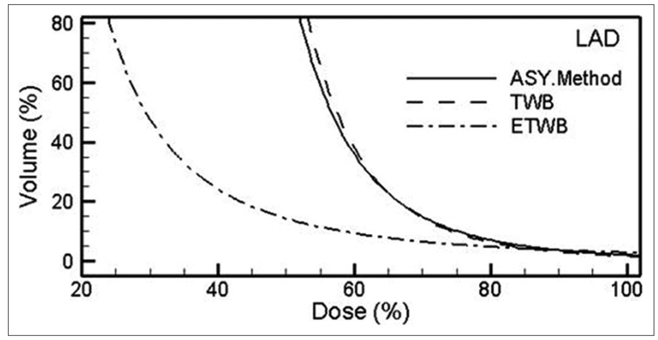


**Figure 2:** Histograms indicating the dose versus volume for the left anterior descending artery

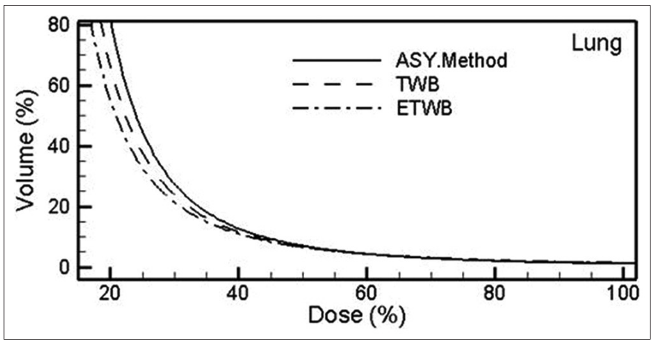


**Figure 3:** Histograms indicating the dose versus volume for the ipsilateral lung

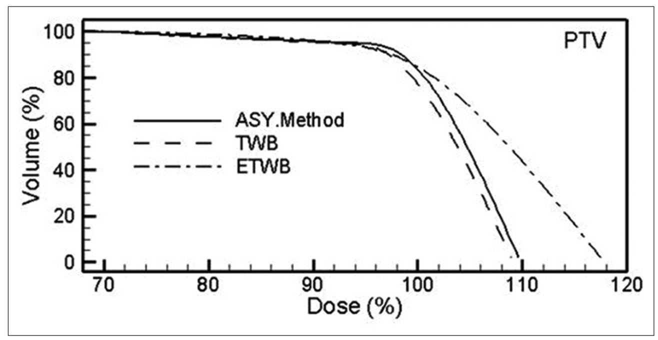


**Figure 4:** Histograms indicating the dose versus volume for the planning target volume

## Pulmonary doses

The Dmean irradiated to the left lung was less in the asymmetric (25.85 ± 5.97) and electron-boosted TWB (25.53 ± 7.6) techniques compared with the TWB technique (27.88 ± 5.92) ($P = 0.001$ and $P = 0.01$, respectively). However, no significant difference was found between the asymmetric and electron-boosted TWB techniques in terms of average dose to the ipsilateral lung ($P = 0.75$).

The mean relative lung volume irradiated to ≥20 Gy was 26.28% ± 6.5% for asymmetric method, which was comparable to that for TWB (27.32% ± 6.3%, $P = 0.1$) and electron-boosted TWB (24.4% ± 8.3%, $P = 0.09$) techniques. The mean CLD was significantly increased from 18.03 ± 4.5 cm with asymmetric RT to 37.47 ± 5.6 cm with TWB and to 27.67 ± 3.8 cm with electron-boosted TWB techniques ($P < 0.0001$ for both). The mean CLD was also significantly increased with TWB technique compared with the electron-boosted TWB technique ($P < 0.0001$) [Table 2].

# Discussion

RT treatment for left breast cancer affects the adjacent critical structures, especially heart and lungs.[2-4] In addition, the breast tissue nonhomogeneous contour results in nonhomogeneity dose distribution and hotspots. The best treatment design would be to achieve a more homologous dose distribution across the breast tissue and a minimum dose irradiated to the OARs.[10,11] RT techniques vary between institutions depending on their facilities. Here, we compared our institutional RT plan with two other left-sided breast RT techniques (tangential breast irradiation with and without electron boost) in terms of the cardiac and pulmonary dose reduction and dose distribution homogeneity of the target organ.

The tangential breast irradiation is a TWB technique in which the irradiation of the heart and ipsilateral lung tissue is usually inevitable. The field-in-field technique, also known as forward IMRT, is one of the best techniques for sparing OAR with comparable PTV dose coverage levels.[12,13] However, it cannot be performed in centers without a multileaf collimator. Combined photon and electron beam therapy is an alternative technique with the ability to reduce the OAR radiation.

In this method, trying to separate the heart and lung tissue from central and lateral tangential parts leads to an increase of the gantry angle while the dose reaching the medial portion of the breast tissue is decreased. The electron field is used to compensate this dose deficit because of the low density of this part of the breast. However, optimizing the dose distribution is challenging in this method and daily match line control is mandatory.[14,15]

Our institutional RT technique is the combination of asymmetric and symmetric fields with common that also spares the heart and lung. Moreover, there is no need for frequent control of match lines or special facilities such as multileaf collimator. Although the electron-boosted TWB technique had the lowest Dmean of LAD (37.04 ± 21.88), our asymmetric RT plan had a significantly lower mean LAD coronary artery dose compared with the TWB method (55.21 ± 18.68 vs. 60.55 ± 16.05, $P = 0.03$). Interestingly, the maximum dose ($P < 0.0001$) and V25 ($P < 0.0001$) of the heart were both lower in the asymmetric technique rather than the TWB RT. The Dmean of the left lung was also significantly reduced in our institutional RT plan compared with the TWB method ($P < 0.0001$), while it was comparable between the asymmetric and electron-boosted TWB techniques. The CLD and, consequently, the absolute lung volume under irradiation were the lowest in the asymmetric technique (18 mm) versus TWB and electron-boosted TWB methods.

The average and maximum PTV doses were found to be higher with electron-boosted TWB method compared to the other two RT techniques. No significant difference was found in terms of the mean or maximum dose of PTV between asymmetric and TWB techniques. However, V50 was comparable between all the three methods.

Our findings showed that the asymmetric RT method in our institution improved the DVH parameters of the heart and lung, while it had no significant effects on the PTV coverage.

## Conclusion

In the centers where multileaf collimator is not available, the asymmetric technique is useful for patients with left-sided breast cancer, which leads to an acceptable PTV coverage with considerably reduced cardiopulmonary doses. Further studies with longer follow-up period are necessary to identify the long term complications of asymmetric RT technique on heart and lungs.

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### Conflicts of interest

There are no conflicts of interest.

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