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Comparison Between Different Photon- and Electron-Treatment Techniques Used for Left Breast Cancer Boost Dose Delivery.

H.I, Abdelkader [1], Ehab A. Hegazy [2], Mohamed E. Abdraboh [3], Aly M. Elhadidy [4]

Abstract— An additional boost dose of 10 to 16 Gy delivered to the tumor bed has shown an additional gain in decreasing local recurrence in patients. In this study a comparison between three different techniques by which the boost dose was delivered to the tumor bed was carried out, aiming to present the best technique of treatment for left breast cancer patients. Ten left sided breast cancer computed tomography (CT) scans were selected for ten early left breast cancer patients. More precautions should be taken to minimize the side effect on heart because the left breast is nearer to the heart than the right breast. Three different treatment plans have been made for each patient CT using three different irradiation techniques to deliver a prescribed boost dose of 10 Gy in 5 fractions to the boost planning target volume (PTV). In the first technique two tangential photon beams have been used, in the second technique two oblique photon beams have been used and in the third technique a single electron beam has been used. The comparative analyses between the three techniques were performed by comparing the boost PTV- dose volume histograms (DVHs), the ipsilateral breast DVHs, the ipsilateral lung DVHs and the heart DVHs of the three techniques for each patient. Furthermore D_{100}, D_{95} (the dose that covering 100%, 95% of the volume) and V_{95} of the boost PTV were calculated in all techniques for each patient, to investigate the dose coverage of the target. Results showed that there were variations of the dose received by tumor bed, left breast and organs at risk (OARs) depending on the technique used and the target location and size. A decrease of D_{100} than 90% of the prescribed dose was observed with the 2nd technique for patients 1, 6 and 7, and was observed with the 1st technique for patient 6, and observed for patient 8 with the 3rd technique. A reduction of left breast dose was observed when the 3rd technique has been used in comparison with the 1st and the 2nd techniques for patients 1, 2, 3, 4 and 5. An increase of lung dose was observed with the 3rd technique for patients 2 and 7, also was observed with 1st technique for patient 1. It was concluded that an individualized treatment and several plans using different irradiation techniques should be developed for each patient to reach the best boost PTV dose coverage with minimal OARs' dose.

Keywords—Boost dose, breast cancer, computed tomography, dose volume histograms, electron beam, linear accelerator, photon beams.

1 Introduction

Breast cancer is considered as the second diagnosed type of cancer "after non-melanoma skin cancer" in women with about 23% of total new cancer cases. Also it represents about 14% of cancer death among women [1].

By the advances of the breast cancer treatment, the breast conserving therapy (BCT) became an accepted option for the treatment of most stage I or II invasive breast cancer in women instead of mastectomy. BCT is a technique of cancer treatment where the breast-conserving surgery (BCS) is used followed by adjuvant postoperative radiotherapy [2]. The use of BCT improves the local control and the survival rate in early stage breast cancer patients [3] with decreasing of both cancer recurrence risk by 70% and death risk by 9%-12% [4].

The two tangential fields is the most common and traditional technique used in the whole breast radiotherapy because of its technical simplicity, more over it has an advantage in sparing organs at risk (OARs). Over the last decade, this technique has evolved by the use of multi-leaf collimators (MLC) to deliver field-in-field (FIF) three-dimensional conformal therapy (3D-CRT) [5], [6] and intensity modulated radiation therapy (IMRT) variants [7], [8].

An additional boost dose of 10 to 16 Gy delivered to the tumor bed has shown an additional gain in decreasing local recurrence in patients [9]. The delivery of the boost dose to tumor bed has been performed sequentially following to the whole breast radiation therapy (RT).

1-Ass. Prof. physics department, faculty of science
Mansoura University.E-mail: hikader5@yahoo.com
2- Lecturer of medical physics, Faculty of engineering
Delta University for science and technology.E-mail: ehabhegazy99@yahoo.com
3- Lecturer of cell and molecular biology, Faculty of science
Mansoura University.E-mail: mohabdraboh@gmail.com
4- PhD student, Faculty of engineering
Delta University for science and technology.E-mail: alyhadidy@yahoo.com

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This Sequential boost reduces local recurrence [10] but increases the treatment duration. Alternatively, the simultaneously integrated boost (SIB) technique has also been involved to BCT with the use of IMRT in breast cancer. With this method, the whole breast and the boost PTV are integrated in a single treatment plan [11].
It was usual to deliver the boost dose to the tumor bed by using the electron beam. But today there are other boost techniques using the photon beam. Up till now, it is unclear which technique is recommended [9]. So investigations are needed to describe the differences between them and to modify a new techniques to irradiate breast with minimal side effects on heart, lungs, skin and normal breast tissues.

In this work, a comparison between three different techniques by which the boost dose was delivered to the tumor bed in left breast was done, aiming to present the best technique of treatment for left breast cancer patients. Since the left breast is nearer to the heart than the right breast so more precautions should be taken to minimize the side effect on heart. In the first technique two tangential photon beams have been used, in the second technique two oblique photon beams have been used and in the third technique a single electron beam has been used.

2 Methods

Ten left sided breast cancer computed tomography (CT) scans were selected for ten early breast cancer patients treated at Ayadi Al-Mostakbal Oncology Center, Alexandria, Egypt. Patients were treated with BCT after BCS. The CT scans were performed by CT system Somatom Emotion Duo (Siemens, Munich, Germany). Patients were scanned according to the standard protocol with 5 mm slice thickness, in the supine position and arms above head [3]. Targets of different locations (upper, lower, medial, inner, outer, deep and superficial) and sizes were selected.

The contouring of target and OARs was done by experienced radiation oncologist. The boost clinical target volume (boost CTV) that included the tumor bed was recognized by the scar, visualized seroma and surgical clips.

The boost planning target volume (boost PTV) that included boost CTV and safety margin of 7 mm in all directions except for the skin, was delineated. Also the ipsilateral breast (left breast), ipsilateral lung (left lung), heart and whole ipsilateral breast volume less boost PTV were delineated.

Three different treatment plans for each patient CT were made using three different irradiation techniques to deliver a prescribed boost dose of 10 Gy in 5 fractions to the boost PTV, and decrease the dose delivered to ipsilateral breast, contralateral breast and OARs. The planning aim was that the volume receiving 95% of the prescribed dose (V_{95}) of the boost PTV to be greater than 95% of the total boost PTV volume, and the volume that receiving 5 Gy of OARs except ipsilateral breast shouldn't exceed 5% of the total organ volume. All plans were performed by a 3D planning system CMS Xio v4.5 (Elekta AB, Stockholm, Sweden) employing the superposition algorithm which combines the effect of both TERMA "total energy released per unit mass" by primary photon [T(r`)] and Kernels [K(r ; r`)] that describes the energy deposited at point (r) by secondary particle originated at (r`), and mathematically expressed as:

$$D(r) = \int T(r') \cdot K(r ; r') \, d^3 r$$

All these plans were created for Siemens Artiste® Treatment System Linear Accelerator (Linac) machine with a dual energy X-rays of 6 and 10 MV and multi-electron beam energies of 10, 15, 16 and 21 MeV. The beams produced have high dose rates (up to 600 cGy per minute), small penumbras (an 80% to 20% penumbra of 6 mm for 6 MV beams), and minimal field edge divergence at 100 cm source-to-surface distance (SSD). The machine gantry, collimator and table can rotate about isocenter point at 100 cm SSD. Gantry and collimator have rotation range of 360°. The machine provides stationary and moving radiation (arc or rotation) clockwise or counter clockwise for X-ray or electron beam. The machine head is provided with conventional collimators in X-direction and two backup diaphragms in Y-direction. Multileaf collimator (MLC) has two opposing sets, having 160-leaf multileaf collimator (MLC) with leaf width of 5mm and leaf-positioning accuracy of 0.5 mm. The machine provides field sizes ranging from 1x1 to 40x40 cm^2 at 100 cm SSD within accuracy ±1 mm for fields less than 20x20 cm^2 and 1% for greater fields.

In the first technique two tangential photon beams were used to deliver the boost dose to the boost PTV and reduce unnecessary dose to OARs. The isocenter located approximately in the center of boost PTV.

In the second technique two oblique photon beams were used with individual selected gantry angle to deliver boost dose to the boost PTV and reduce unnecessary dose to OARs. The isocenter located approximately in the center of boost PTV.

In the third technique a single direct electron beam was used with SSD =100 cm to deliver the boost dose to the boost PTV and reduce unnecessary dose to OARs.

For all techniques, the beam energy was chosen for each case individually depending on the target location and volume aimed to cover the boost PTV with 95% of the prescribed dose.
The isodose distributions and dose volume histograms (DVHs) of the three techniques for the boost PTVs and OARs, were obtained by using 3D planning system CMS Xio v4.5 (Elekta AB, Stockholm, Sweden) for each patient
The comparative analyses between the three techniques were performed by comparing the boost PTV-DVHs, the ipsilateral breast (left breast) DVHs, the ipsilateral lung (left lung) DVHs and the heart DVHs of the three techniques for each patient.
Furthermore D_{100}, D_{95} (the dose that covering 100%, 95% of the volume) and V_{95} of the boost PTV were calculated in all techniques for each patient, to investigate the dose coverage of the target. Also the volume receiving 5 Gy of OARs of all techniques were calculated for each patient.

3 Results

In this work boost dose of 1000 cGy delivered to tumor bed of

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left breast cancer for ten patients were estimated using three different radiotherapy techniques. The techniques used were two opposite tangential photon beams (1st technique), two oblique photon beams (2nd technique) and single electron beam (3rd technique). The isodose distributions were carried out for every technique and DVHs for boost PTV, ipsilateral breast, left lung and heart using different techniques were analyzed and compared.

TABLE 1

PRESENTED THE TARGET POSITION, TARGET DIMENSION, AND OARS POSITION

Patient	Location	Target height x width (cmxcm)	Distance between target and skin (cm)	Target depth (cm)	Distance between target and lung (cm)	Distance between target and Heart (cm)
1	Inner- Medial	3.0x6.0	0.5	5.0	Far	1.0
2	Outer - Upper	4.5x4.5	0.5	4.5	1.5	7.5
3	Outer -Medial	2.5x2.5	2.0	4.0	3.4	8.0
4	Central - Upper	3.5x5.0	0.5	5.0	2.5	9.0
5	Central - Lower	3.0x4.0	3.0	5.1	1.9	Far
6	Central - Medial	1.5x4.0	0.1	3.0	5.0	Far
7	Central - Medial	3.0x6.5	0.5	4.5	1.5	5.0
8	Central - Upper	4.0x8.5	2.0	6.0	2.0	7.0
9	Central - Upper	2.5x3.5	2.0	4.3	1.2	Far
10	Outer - Lower	3.0x4.5	0.5	5.7	2.0	70

For patient 1, the isodose distributions using the three techniques are shown in Fig. (1). It's clear that the boost PTV coverage for each technique was accepted.

The DVHs of boost PTV, ipsilateral breast, left lung and heart using the three techniques are shown in Fig. (2).

From the boost PTV-DVHs of all treatment plans, we see similar boost PTV dose coverage, as shown in Fig. (2-a). D_{95} of the boost PTV was greater than 950 cGy (95%of therapeutic dose) and V_{95} of the boost PTV was greater than 95% for all techniques. A slight decrease of D_{100} = 854.505 cGy than 90 % of the therapeutic dose was observed for 2nd technique while D_{100} = 900.22 cGy for 3rd technique and D_{100} = 921.319 cGy for 1st technique.

From the left breast DVHs shown in Fig. (2-b), it was clear that the 3rd technique presented the lowest breast dose. The volumes received doses (up to 900 cGy) were decreased by about 51% when the 3rd technique used in comparison with the 1st technique. The 3rd technique was better than the 2nd technique because it reduced the volumes received doses (up to 300 cGy) and (>300-500 cGy) by 44% and 16% respectively. In the region of doses greater than (500 cGy) the DVHs of the 2nd and the 3rd techniques were almost similar. These results indicated that the 3rd technique was favorable than the two other techniques.

Fig. (2-c) shows that the left lung DVHs for all techniques were almost similar. Also it is clear that the volumes received dose of 500 cGy (V_{50}) didn't exceed 5% of total volume for all technique. A slight increase of V_{50} for left lung was observed with the 1st technique and it was about 4.6%.

The analysis of heart DVHs for all techniques indicated that the 2nd technique presented the highest heart dose in comparison with the 1st and the 3rd techniques, as shown in Fig. (2-d). The volumes received doses (up to 400 cGy) were decreased by about 87% and 67% when the 1st and 3rd techniques were used respectively in comparison with the 2nd technique. For high doses (greater than 500cGy) the DVH for all techniques was almost similar. Also (V_{50}) didn't exceed 5% of total volume for all techniques.

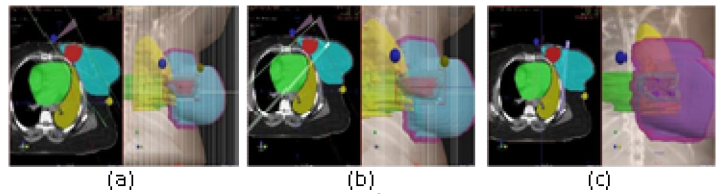

Fig. 1. The isodose distributions for patient 1. (a) Two opposite tangential photon beams, (b) Two oblique photon beams and (c) Single electron beam.

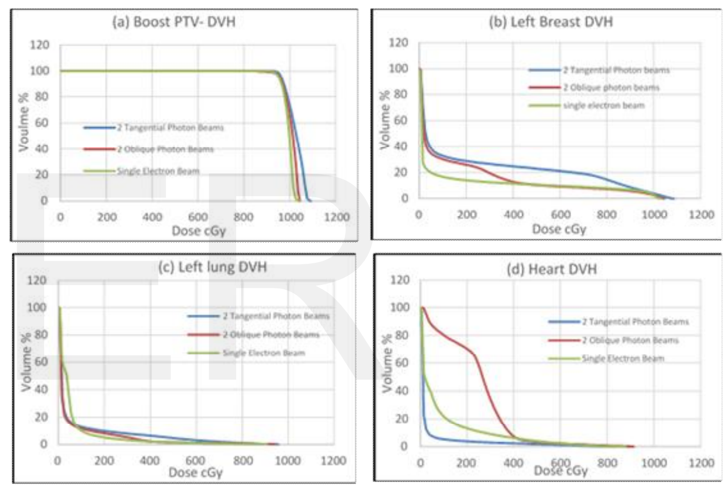

Fig. 2. The comparisons between DVHs of patient 1 using two opposite tangential photon beams, two oblique photon beams and single electron beam for (a) Boost PTV, (b) Left breast, (c) left lung and (d) Heart.

For patient 2, the isodose distributions using the three techniques are shown in figure (3). It's clear that the boost PTV coverage for each technique was accepted.

The DVHs of boost PTV, ipsilateral breast, left lung and heart using the three techniques are shown in figure (4).

From the boost PTV-DVHs for all techniques, shown in figure (4-a), similar boost PTV dose coverage was seen. D_{95} was greater than 950 cGy and V_{95} was greater than 95% for all techniques.

From the left breast DVHs shown in figure (4-b), it was clear that the 3rd technique presented the lowest breast dose. The volumes received doses (up to 900 cGy) were decreased by about 45% when the 3rd technique used in comparison with the 1st technique. The 3rd technique was better than the 2nd technique that it reduced the volumes received doses (up to 300 cGy) and (>300-900 cGy) by 45% and 35% respectively. These results indicated that the 3rd technique was favorable than the two other techniques.

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By the analysis of Lung and heart DVHs for all techniques, shown in figures (4-c) and (4-d) respectively. An increase of lung doses were observed for the 3rd technique that V_{50} reached 4.7%. Also a slight increase of heart doses were observed for the 1st technique.

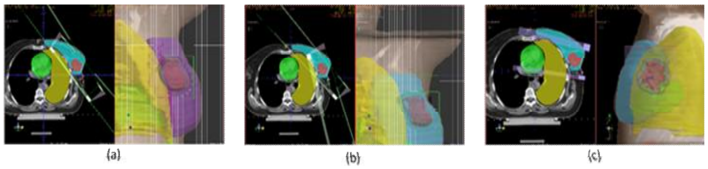

Fig. 3. The isodose distributions for patient 2. (a) Two opposite tangential photon beams, (b) Two oblique photon beams and (c) Single electron beam.

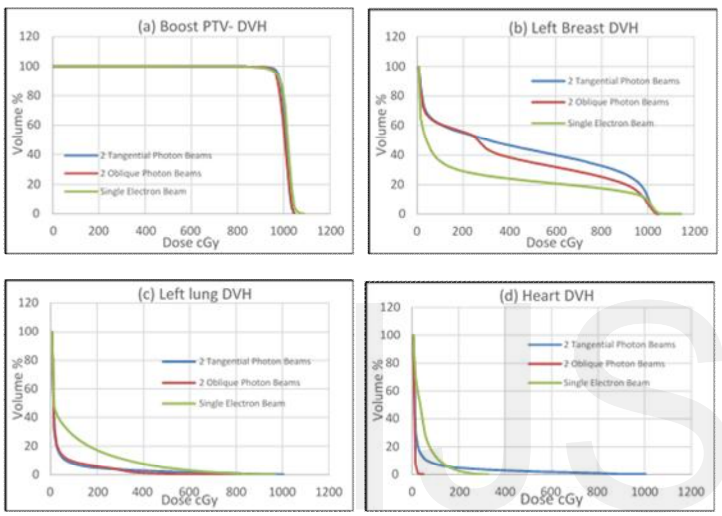

Fig. 4. The comparisons between DVHs of patient 2 using two opposite tangential photon beams, two oblique photon beams and single electron beam for (a) Boost PTV, (b) Left breast, (c) left lung and (d) Heart.

For patient 3, the isodose distributions using the three techniques are shown in Fig. 5. It's clear that the boost PTV coverage for each technique was accepted.

The DVHs of boost PTV, ipsilateral breast, left lung and heart using the three techniques are shown in Fig. 6.

From the boost PTV DVHs for all treatment plans shown in Fig. (6-a), similar boost PTV dose coverage was seen. D95 was greater than 950 cGy and V95 was greater than 95% for all techniques. Also D100 was greater than 90 % of the therapeutic dose for all techniques

From the left breast DVHs shown in Fig. (6-b), it was clear that the 3rd technique presented the lowest left breast dose. The volumes received doses (up to 900 cGy) were decreased by about 51% when the 3rd technique used compared to the 1st technique. Also the volumes received doses (up to 400 cGy) were decreased by about 44% when the 3rd technique used in comparison with the 2nd technique. These results indicated that the 3rd technique was favorable than the two other techniques.

By the analysis of Lung and heart DVHs for all techniques, shown in Figs. (6-c) and (6-d) respectively, there were no significant differences between the three techniques. A slight increase of lung doses were observed for the 3rd technique. (V_{50}) didn't exceed 5% of total volume for all techniques.

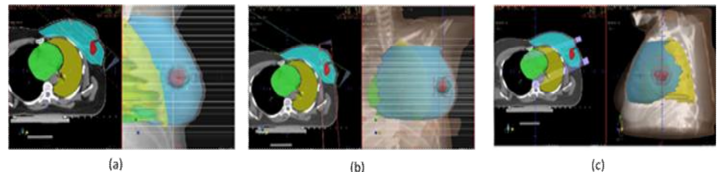

Fig. 5. The isodose distributions for patient 3. (a) Two opposite tangential photon beams, (b) Two oblique photon beams and (c) Single electron beam.

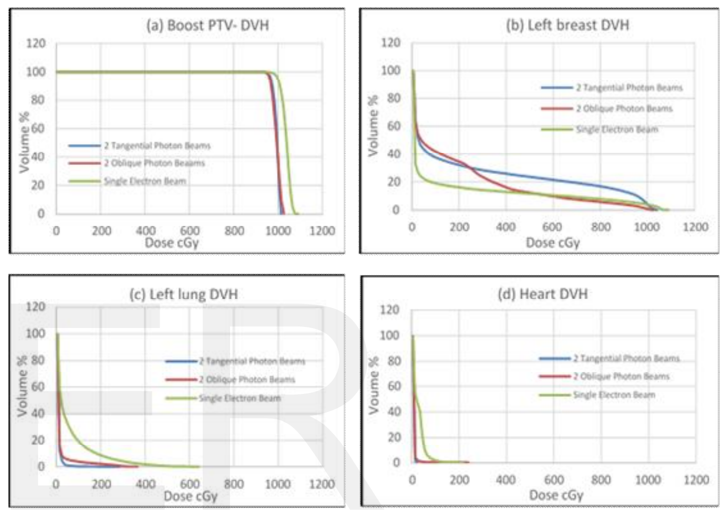

Fig. 6. The comparisons between DVHs of patient 3 using two opposite tangential photon beams, two oblique photon beams and single electron beam for (a) Boost PTV, (b) Left breast, (c) left lung and (d) Heart.

For patient 4, the isodose distributions using the three techniques are shown in figure (7). It's clear that the boost PTV coverage for each technique was accepted.

The DVHs of boost PTV, ipsilateral breast, left lung and heart using the three techniques are shown in figure (8).

From the boost PTV DVHs for all treatment plans shown in figure (8-a), similar boost PTV dose coverage was seen. D_{95} was greater than 950 cGy and V_{95} was greater than 95% for all techniques.

From the left breast DVHs shown in figure (8-b), a significant decrease of breast dose was observed with the 3rd technique. The volumes received doses (up to 900 cGy) were decreased by about 69% when the 3rd technique used in comparison with the 1st technique. Also the volumes received doses (up to 300 cGy) and (>300-900 cGy) were decreased by 50% and 35% respectively when the 3rd technique used in comparison with the 2nd technique.

By the analysis of Lung and heart DVHs for all techniques, shown in figures (8-c) and (8-d) respectively, there were nosignificant differences between the three techniques. A

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slight increase of lung doses were observed for the 3rd technique. (V_{50}) didn't exceed 5% of total volume for all techniques.

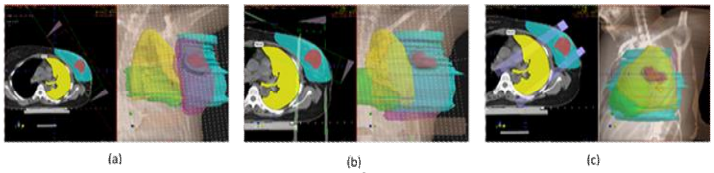

Fig. 7. The isodose distributions for patient 4. (a) Two opposite tangential photon beams, (b) Two oblique photon beams and (c) Single electron beam.

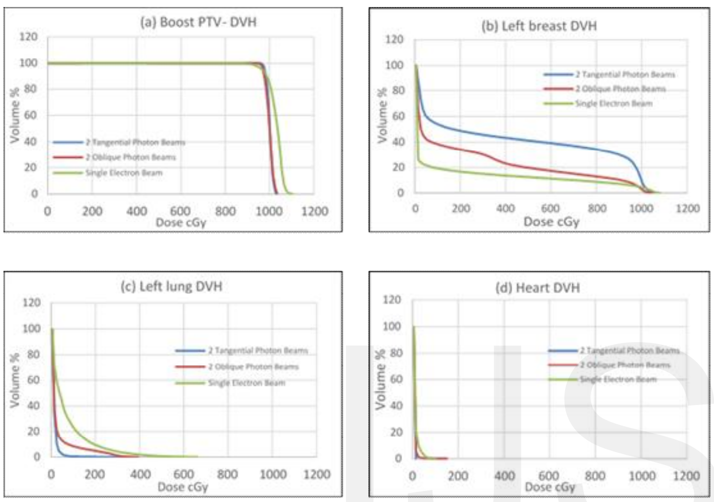

Fig. 8. The comparisons between DVHs of patient 4 using two opposite tangential photon beams, two oblique photon beams and single electron beam for (a) Boost PTV, (b) Left breast, (c) left lung and (d) Heart.

For patient 5, the isodose distributions using the three techniques are shown in figure (9). It's clear that the boost PTV coverage for each technique was accepted.

The DVHs of boost PTV, ipsilateral breast, left lung and heart using the three techniques are shown in figure (10).

From the boost PTV DVHs of all treatment plans, we see similar boost PTV dose coverage, as shown in figure (10-a). D_{95} was greater than 95%of therapeutic dose and V_{95} was greater than 95% for all techniques. D_{100} for each technique was greater than 90 % of the therapeutic.

From the left breast DVHs shown in figure (10-b), a significant increase of breast dose was observed with the 1st technique. The volumes received doses (up to 900 cGy) were decreased by about 55% when the 3rd technique used in comparison with the 1st technique. Also the volumes received doses (>400cGy) were decreased by about 58% when the 2nd technique used in comparison with the 1st technique. Comparing between 2nd and 3rd techniques showed that the volumes received doses (up to 400 cGy) were decreased by 47% with the 3rd technique, while at region of doses (>400cGy) there was no significant difference between them. These results indicated that the 1st technique was unfavorable than the two other techniques.

By the analysis of Lung and heart DVHs for all techniques, shown in figures (10-c) and (10-d) respectively, there were no significant differences between the three techniques. A slit increase of lung doses were observed for the 2nd technique in region of doses (100-300 cGy). (V_{50}) didn't exceed 5% of total volume for all techniques.

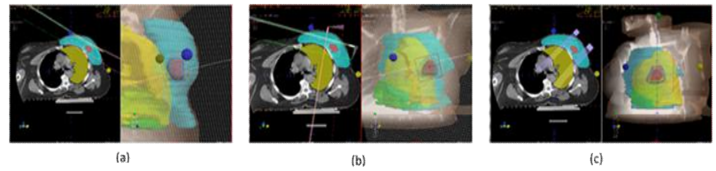

Fig. 9. The isodose distributions for patient 5. (a) Two opposite tangential photon beams, (b) Two oblique photon beams and (c) Single electron beam.

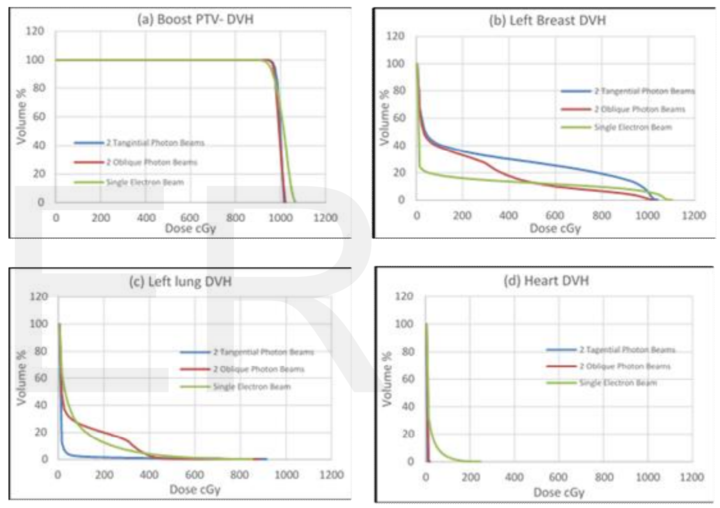

Fig. 10. The comparisons between DVHs of patient 5 using two opposite tangential photon beams, two oblique photon beams and single electron beam for (a) Boost PTV, (b) Left breast, (c) left lung and (d) Heart

For patient 6, the isodose distributions using the three techniques are shown in Fig. (11).

The DVHs of boost PTV, ipsilateral breast, left lung and heart using the three techniques are shown in Fig. (12).

From the boost PTV DVHs of all treatment plans, it was observed that the 3rd technique presented the best boost PTV dose coverage, as shown in Fig. (12-a). D_{95} was greater than 950 cGy for the 3rd technique, while it was about 782 cGy and 648 cGy for the 1st and the 2nd techniques respectively. V_{95} was greater than 95% for the 3rd technique, while it was about 75% and 66 % for the 1st and the 2nd techniques respectively. Also D_{100} was about 876 cGy for the 3rd technique, while it was about 454 cGy and 377 cGy for the 1st and the 2nd techniques respectively.

By the analysis of left breast, lung and heart DVHs for all techniques, shown in Figs. (12-b), (12-c) and (12-d)

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respectively, there were no differences between the three techniques. (V_{50}) in lung and heart didn't exceed 5% of total volume for all techniques.

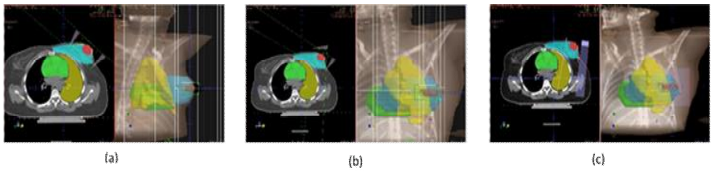

Fig. 11. The isodose distributions for patient 6. (a) Two opposite tangential photon beams, (b) Two oblique photon beams and (c) Single electron beam.

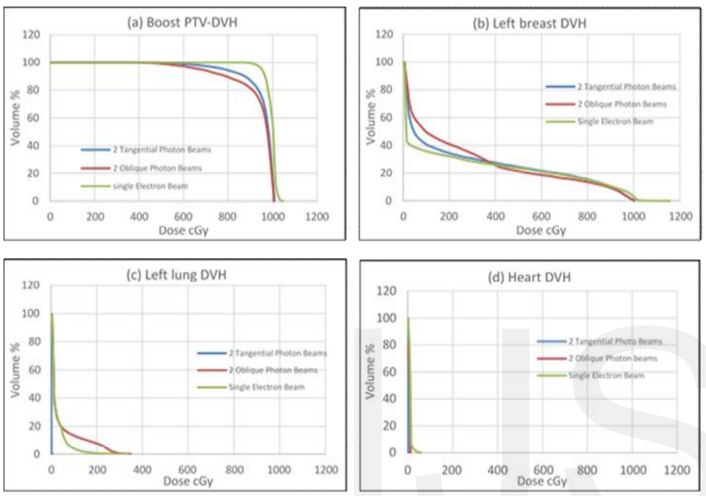

Fig. 12. The comparisons between DVHs of patient 6 using two opposite tangential photon beams, two oblique photon beams and single electron beam for (a) Boost PTV, (b) Left breast, (c) left lung and (d) Heart

For patient 7, the isodose distributions using the three techniques are shown in figure (13). It's clear that the boost PTV coverage for each technique was accepted.

The DVHs of boost PTV, ipsilateral breast, left lung and heart using the three techniques are shown in figure (14).

From the boost PTV DVHs of all treatment plans, similar boost PTV dose coverage was noticed, as shown in figure (14-a). D_{95} was greater than 95%of therapeutic dose and V_{95} was greater than 95% for all techniques. A slight decrease of D_{100} = 768 cGy than 90 % of the therapeutic dose was observed for the 2nd technique while D_{100} = 936 cGy for the 3rd technique and D_{100} = 916 cGy for the 1st technique.

By the analysis of boost PTV, left breast and heart DVHs for all techniques, shown in figures (12-a), (12-b) and (12-d) respectively, There were no effective differences between the three techniques. (V_{50}) for heart didn't exceed 5% of total volume for all techniques. From left lung DVH shown in figure (12-c) it was found that there was an increase in lung dose when the 3rd technique was used and (V_{50}) reached 5% of the total volume. It was clear that the lowest heart and left lung dose was obtained with the 1st technique.

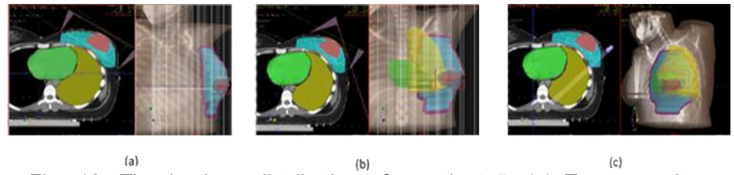

Fig. 13. The isodose distributions for patient 7. (a) Two opposite tangential photon beams, (b) Two oblique photon beams and (c) Single electron beam.

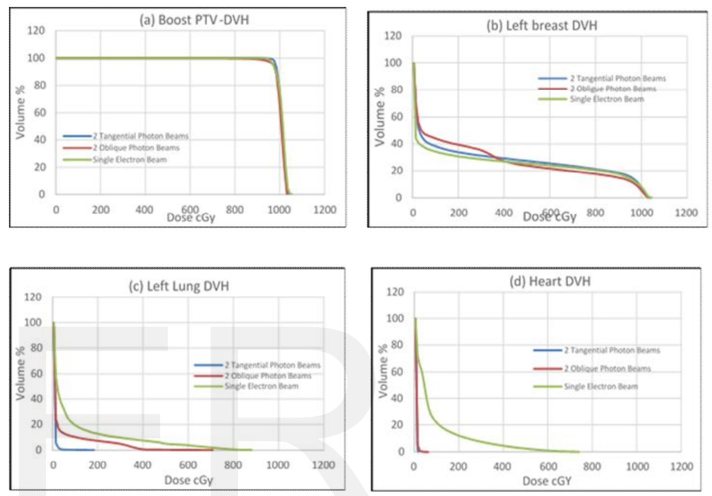

Fig. 14. The comparisons between DVHs of patient 7 using two opposite tangential photon beams, two oblique photon beams and single electron beam for (a) Boost PTV, (b) Left breast, (c) left lung and (d) Heart

For patient 8, the isodose distributions using the three techniques are shown in Fig. 15.

The DVHs of boost PTV, ipsilateral breast, left lung and heart using the three techniques are shown in Fig. 16, noting that the 3rd technique was made by two different energies (1) lower energy (15 MeV) and (2) higher energy (21 MeV).

From the boost PTV DVHs of all treatment plans, we see similar boost PTV dose coverage for the 1st and the 2nd techniques and poor coverage for the 3rd technique with lower energy, as shown in Fig. (16-a). Decreases of D_{100} = 733 cGy, D_{95} =846 cGy and V_{95} = 69% were observed for the 3rd technique with lower energy.

From the left breast DVHs shown in Fig. (16-b), there were no effective differences between the 1st and the 2nd techniques. For the 3rd technique with higher energy we observed that the maximum dose received by left breast increased to about 120% of therapeutic dose.

By the analysis left lung and heart DVHs for all techniques, shown in Figs. (16-c) and (16-d) respectively, we didn't find any significant differences between the three techniques. (V_{50})

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didn't exceed 5% of total volume for all techniques. But it was clear that the lowest heart and left lung dose was obtained with the1st technique.

It is clear that the 3rd technique wasn't preferable for this case.

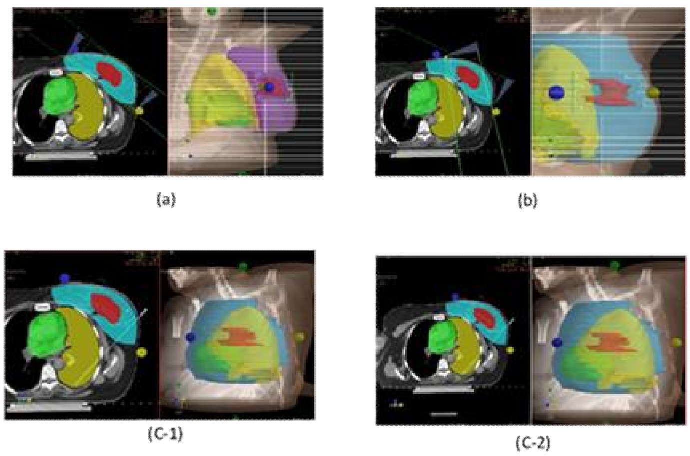

Fig. 15. The comparisons between DVHs of patient 8 using two opposite tangential photon beams, two oblique photon beams and single electron beam for (a) Boost PTV, (b) Left breast, (c-1) Single electron beam with lower energy and (c-2) Single electron beam with higher energy.

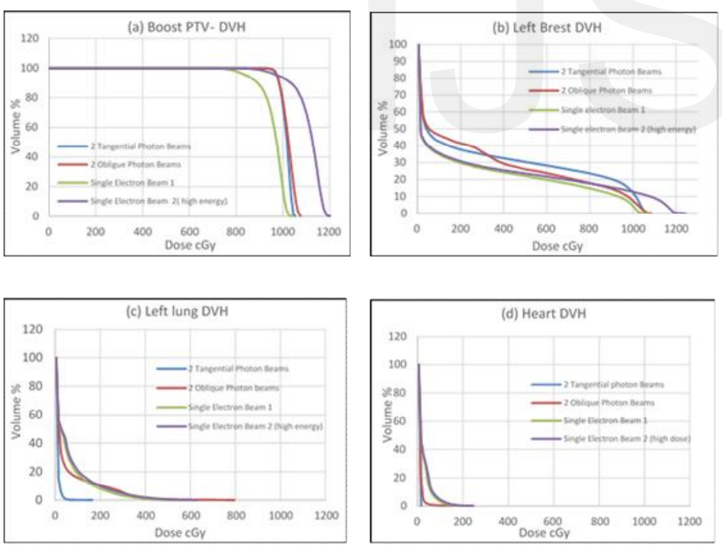

Fig. 16. The comparisons between DVHs of patient 8 using two opposite tangential photon beams, two oblique photon beams and single electron beam for (a) Boost PTV, (b) Left breast, (c) left lung and (d) Heart

The isodose distributions using the three techniques for patient 9 and patient 10 are shown in Fig. 17 and Fig. 18 respectively.

For patient 9, the tumor bed located central as in patient 5 and so the behavior of isodose distributions for patient 9 was similar to patient 5. However, the tumor bed was upper and the left lung was closer to the tumor bed in patient 9 than in patient 5. By the analysis of left lung DVHs for all techniques, an increase in the lung dose was noted when the 3rd technique was used and (V_{50}) reached 4.9% of the total volume.

For patient 10, the tumor bed located outer as in patient 2. However, the tumor bed was lower, deeper and the left lung was further far from the tumor bed in patient 10 than in patient 2. By the analysis of tumor bed DVHs for all techniques, it was found that the 3rd technique presented the worst target coverage. Also by the analysis of left lung DVHs for all techniques a decrease in lung dose was noted for patient 10 than for patient 2.

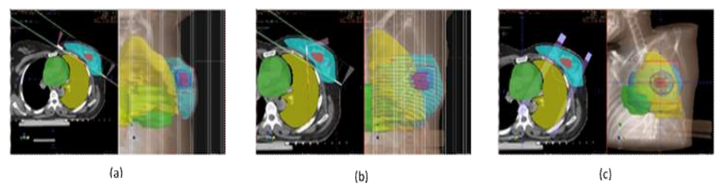

Fig. 17. The isodose distributions for patient 9. (a) Two opposite tangential photon beams, (b) Two oblique photon beams and (c) Single electron beam.

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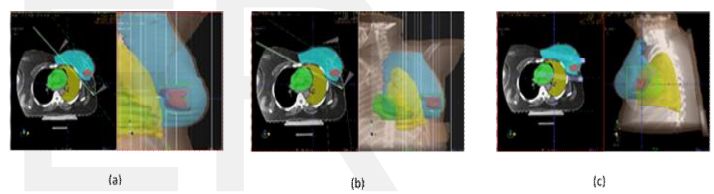

Fig. 18. The isodose distributions for patient 10. (a) Two opposite tangential photon beams, (b) Two oblique photon beams and (c) Single electron beam

4 Conclusions

This work aimed to compare between three different techniques by which a prescribed dose delivered to the left breast boost PTV, to determine the best technique in terms of dose delivery to the boost PTV while maintaining acceptable dose distributions in normal breast tissues and the OARs.

It is concluded that:

1- The 3rd technique presented the lowest dose delivered to the normal breast tissues, however it delivered a high doses to the heart and the left lung in some cases.
2- The 1st technique presented the lowest dose delivered to the heart and the left lung, however it delivered a high doses to the normal breast tissues, and so it could be the technique of choice for young patient or patient with medical back ground showing disorders in heart or left lung.
3- When the lung was closed to the tumor bed, the 3rd technique presented the largest dose deliver to the lung and the volume receiving 500 cGy might reached 5%.

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4- For small size breast (that meaning the distance between the lung and the skin is small), the 3rd technique presented the largest dose deliver to the lung and the volume receiving 500 cGy might reached 5%.
5- As the thickness of breast decrease in the upper part , the lung becomes closer to the skin.so if the target located upper the 3rd technique may deliver a high dose to the lung (except for large size breast).
6- For superficial tumor bed, the 3rd technique presented the accepted boost PTV dose coverage. So it considered as the best technique in delivering boost dose to tumor bed for cancer patient with superficial target.
7- For large and/or deep tumor bed, the 1st technique provided the beast boost PTV coverage with minimal dose delivered to OARs. So it considered as the technique of choice in delivering boost dose to tumor bed for cancer patient with large deep tumor bed. The 3rd technique was unfavorable for this case because of its poor dose coverage to boost PTV.
8- For inner boost PTV located close to the heart, the 2nd technique was unfavorable because it delivered a high dose to the heart, while the 1st technique presented the largest lung dose.

Finally, it wasn't found a definite irradiation technique that could sufficiently deliver the boost dose to the boost PTV and totally spare the OARs, as the treatment planning is multifactorial process affected by multiple factors including radiation type and energy, technique of irradiation, target size, target location, target depth, breast size, distance between target and OARs, distance between the skin and OARs.

It was recommended that there was no standard procedures could be considered as the best technique to deliver the boost dose to tumor bed while maintaining acceptable dose distributions in normal breast tissues and the OARs.

An individualized treatment and several plans using different irradiation techniques should be developed for each patient individually to reach the best boost PTV dose coverage and with minimal OARs' dose.

5 Lists

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