

Optimizing of the Tangential Technique and Supraclavicular Fields in 3 Dimensional Conformal Radiation Therapy for Breast Cancer

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ABSTRACT

Radiotherapy plays an essential role in the management of breast cancer. Three-dimensional conformal radiation therapy (3D-CRT) is applied based on 3D image information of anatomy of patients. In 3D-CRT for breast cancer one of the common techniques is tangential technique. In this project, various parameters of tangential and supraclavicular fields are optimized. This project has been done on computed tomography images of 100 patients in Isfahan Milad Hospital. All patients have been simulated and all the important organs have been contoured by radiation oncologist. Two techniques in supraclavicular region are evaluated including: 1-A single field (Anterior Posterior [AP]) with a dose of 200 cGy per fraction with 6 MV energy. This is a common technique. 2-Two parallel opposed fields (AP-Posterior Anterior [PA]). The dose of AP was 150 cGy with 6 MV energy and PA 50 cGy with 18 MV. In the second part of the project, the tangential fields has been optimized with change of normalization point in five points: (1) Isocenter (Confluence of rotation gantry axis and collimator axis) (2) Middle of thickest part of breast or middle of inter field distance (IFD) (3) Border between the lung and chest wall (4) Physician's choice (5) Between IFD and isocenter. Dose distributions have been compared for all patients in different methods of supraclavicular and tangential field. In parallel opposed fields average lung dose was 4% more than a single field and the maximum received heart dose was 21.5% less than a single field. The average dose of planning tumor volume (PTV) in method 2 is 2% more than method 1. In general AP-PA method because of a better coverage of PTV is suggested. In optimization of the tangential field all methods have similar coverage of PTV. Each method has spatial advantages and disadvantages. If it is important for the physician to reduce the dose received by the lung and heart, fifth method is suggested since in this method average and maximum received dose to heart and lung have been reduced few percent in comparison to other methods. If a better coverage of PTV is important for the physician second method can be an optimized method. In this method, average and maximum received dose to PTV have been increased few percent in comparisons of physician's choice method and three other methods. In optimizing of supraclavicular field AP-PA method due to better coverage of PTV is suggested. In optimizing of tangential all methods are similar. Each method has special advantages and disadvantages. The physicians can change the depth of the normalization point in the breast to get the desired average dose.

Key words: Breast cancer, radiation therapy, treatment planning

INTRODUCTION

Breast cancer is one of the most common cancers in women, with high mortality rate. The incidence of breast cancer is raised year by year, and patients suffered from breast cancer are becoming much younger.^[1]

This kind of cancer with the wide-spread use of mammography can be diagnosed in the early stages.^[2-6] A comprehensive treatment strategy has been applied for breast cancer patients, which includes radical or breast-conserving surgery, radiotherapy, chemotherapy,

endocrine therapy, and immunization therapy.^[7,8] For many years, mastectomy was the standard treatment to achieve local control in breast cancer.^[9-11]

Radiotherapy plays an essential role in the management of breast cancer and many studies have shown better survival of patients after mastectomy followed by radiotherapy.^[12-16]

One general goal of radiation therapy is to protect the healthy tissues adjacent to the tumor. Among the side-effects of radiotherapy are secondary cancer and cardiomyopathy. The reduction of side-effects in radiotherapy is more

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considerable compare to other methods of treatment.^[5] Approximately 120,000 women with breast cancer are treated with radiotherapy annually in the United States.^[17-19] The proportion of patients with breast cancer treated with radiation therapy has increased substantially during the past two decades.^[20-22]

Because the local recurrence is a critical factor for patient mortality, radiation therapy plays an significant role in treatment to prevent local recurrence.^[9,23,24]

One of the common techniques of radiation therapy is Accelerated Partial Breast Irradiation (APBI). APBI has been studied as a possible alternative to conventional whole breast radiation therapy for patients with early-stage breast cancer treated with breast-conserving therapy.^[25]

Several methods to deliver APBI have been developed, including interstitial and intracavitary brachytherapy, external beam radiation therapy, and single-fraction intraoperative treatment.^[26]

3 Dimensional-Conformal radiotherapy is a technique for dose delivery based on 3D images of target volume. 3D-conformal is a technique in which the irradiation beams is shaped to conform the tumor in each direction. In the conventional technique, irradiation beam is usually larger than the tumor. However, in 3D-conformal technique the irradiation beams is shaped to conform to the tumor and prevent to irradiate the other organs.^[27,28] Radiation therapy for breast cancer and chest wall may come with toxic effects such as skin recurrence, soft-tissue fibrosis.^[29-33]

To reduce the risk of radiation toxicity, three-dimensional (3D) treatment planning and dynamic multi leaf collimator (MLC) have been used to modulate the radiotherapy dose in three dimensions across the breast and chest wall. MLC is made of lead plates and this kind of collimator can make various shapes of irradiation beams and it limits irradiation beams to target volume and prevent irradiating other organs. Compare to costume blocks, MLC is very easy to shape and apply to various field shapes.

3D modulation of the radiation beam profile also improves dose homogeneity within the treated breast and it lowers the dose to the contralateral breast and potentially, the heart.^[34-43]

In general, Radiotherapy for breast cancer after mastectomy and breast-conserving surgery include chest wall and for patients with regional lymph node involvement, supraclavicular region regular must irradiated.^[44]

There are limited studies about APBI. In 2005 Moon *et al.* did a dosimetric comparison of three different techniques in APBI and they found that 3D conformal radiation

therapy resulted in better coverage of the planning tumor volume (PTV) compared with Mammo Site or interstitial brachytherapy techniques.^[45] In this study, they did a dosimetric comparison of two different 3D conformal external beam techniques and they found that 3D conformal external accelerated partial breast irradiation provides excellent normal tissue sparing with adequate coverage of PTV.

General points of the tangential treatment technique are mentioned in various papers and books, but its implementation details are not mentioned. The tangential treatment technique is now being treated by physicians in different ways and there is no exact protocol.^[37,46]

The aim of this study is the optimization and comparison of various approaches in supraclavicular and tangential field and finally reaching a proper treatment protocol.

MATERIALS AND METHODS

In radiotherapy for breast cancer usually a dose of 50 Gy is prescribed in 25 fractions.^[47-51] So in the standard radiation therapy daily fractions of 2 Gy (200 cGy) to the whole breast and a boost of 10-16 Gy to the tumor bed is delivered. Patients are usually placed in the supine position on an angled breast board with one or both arms stretched above the head. The position of the patient must be similar in treatment and simulation. The patient is placed on an angled breast board because the sternum slope and chest wall slope is modified. Tangential fields must cover the breast and edges of the field are shaped based on patients' anatomy.

The developments in computer technology allowed the integration of computed tomography (CT)-information in the RT planning system, enabling the design of radiation beams that are based on patient-specific 3D anatomical information. A modern linear accelerator with MLC can deliver these conformal beams to the target. In breast irradiation, the 3D alignment of the tangential beams allows improved coverage of the breast tissue and reduction of the volume of irradiated heart and lung tissue.

Using full CT-data, the location of the match line between the tangential and supraclavicular fields can be matched, depending on the patients' anatomy.

The tangential technique is illustrated in Figure 1. This technique includes the internal mammary lymph nodes. The tangential technique for the treatment of breast and chest wall includes a small part of the lung in this field.

In contouring of CT scans, the treatment volume of axillary veins and supraclavicular area is determined. The photon beam energy is usually 6 MV and the gantry angle is between

50 and 60° for right breast. For large chest walls a higher energy might be used.

In the breast tissue, there are different thicknesses of the tissue in the path of the beam and this can cause a hot spot in the thinner regions. In order to avoid hot spots and achieve more homogeneity isodose for the tangential fields, two wedges with 15-30° angles can be used. In both cases, the thickness of the wedge is placed in the nipple region. Figure 1 illustrates an example of tangential fields for breast and Figure 2 is an example of tangential and supraclavicular fields in the surface of the patient.

Region 1: Supraclavicular

Region 2: Tangential.

The supraclavicular region can be treated either with single or two fields. The supraclavicular region is treated with single-photon field only in the cases that that target is superficial and dose distribution in the target volume is reasonably uniform.

For example, the prescription dose should be approximately $\pm 5\%$ in the tumor and the maximum received dose to tissues should not be more than $\pm 110\%$ of the prescribed dose.

In this project, the CT images of 100 patients in Isfahan Milad Hospital have been used and all the data is imported in the treatment planning system, TPS (TiGRT from Lina Tech). This software is one of the most important tools in radiation therapy and it is able to calculate absorbed dose in various points of tissue for each particular patient. The treatment planning system TiGRT has been commissioned based on ONCOR Siemens linear accelerator information.

In contouring, all the important organs such as breast, heart, lung, and spinal have been contoured by radiation oncologist. Contouring procedures is essential for treatment planning and designing the exact direction of the fields and calculation of dose volume histogram (DVH). DVH is the histogram of volume versus dose. In the ideal case of DVH, the tumor volume must be covered by 100% prescription dose and the dose of critical organs has to be kept up to a certain limit. After contouring various treatment plans are designed. This project includes over 400 different plans.

The first step in this study is optimization of supraclavicular field in which two techniques have been used:

1. A single Anterior Posterior (AP) field (AP) with dose 200 cGy and 6 MV energy
2. Two parallel opposed AP-Posterior Anterior (PA) fields (AP and PA) in which the dose of the AP is 150 cGy and the energy is 6 MV. The dose of the PA is 50 cGy with 18 MV photons.

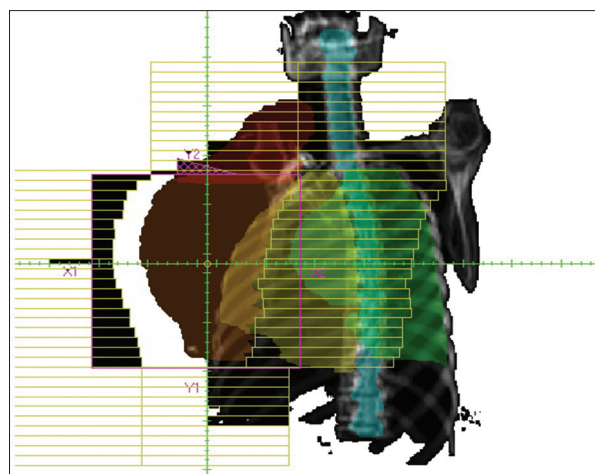


Figure 1: A tangential field in radiotherapy for breast with 15° wedge

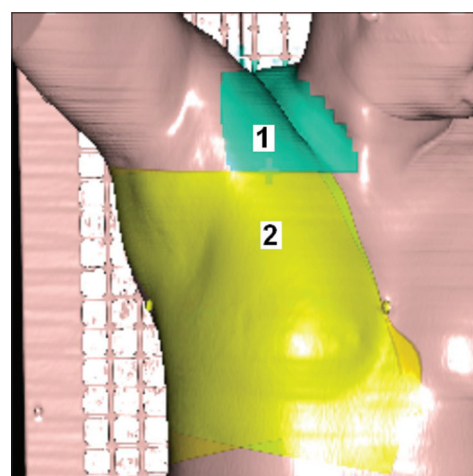


Figure 2: The tangential and supraclavicular areas in radiotherapy for breast

Figures 3 and 4 illustrate AP-PA technique and AP technique which are shaped according to gross tumor volume. According to recommendations, the fields are rotated 15° in the opposite direction of the spine to avoid the spine.

The second part of this project is the optimizing of tangential field. One technique in order to change the dose distribution is changing the depth of the normalization point. The normalization point is a point that is supposed to receive 100% of the prescription dose. The TPS increases the amount of radiation until this point receives the prescribed dose. The normalization point is positioned in four various locations, which are illustrated in the Figures 5 and 6.

The locations of four points are as follows:

- P_1 : Isocenter (the gantry rotates around this point and the axis of all beams intersects in this point)
- P_2 : Middle of inter field distance (IFD) and isocenter
- P_3 : Border between the lung and chest wall
- P_4 : Middle of the thickest part of breast or middle of IFD.

The dose distributions with these points are compared to the point that the physician has determined. This should be noted that physician choice is the one that is used in reality and the patient is irradiated according to that point. The physician choice could be any of the four points and it is usually in the isocenter (P1). The dose distribution and DVH is calculated for PTV, lung, heart, and spinal each four techniques. With comparing these results, the best point is selected. In this project for data analyzes SPSS 16 statistical software was used.

DISCUSSION AND RESULTS

TPS software after calculating the DVH for each technique calculates automatically the average dose and maximum dose for each organ that have been contoured.

The isodose curves for 100 patients in both supraclavicular and tangential fields were compared and dose distributions for each patient in all techniques were studied.

In optimizing of supraclavicular field in the single field technique the average received supraclavicular dose was 4654 cGy with a standard deviation of 469 and in AP-PA technique average received supraclavicular dose was 4754 cGy with a standard deviation 387. In a single field technique, maximum received supraclavicular dose was 6705 cGy with a standard deviation 1210 and in AP-PA technique Maximum received supraclavicular dose was 6582 cGy with a standard deviation 1206. An example of dose distribution in single and AP-PA technique are illustrated in Figures 7 and 8.

Dose distribution in Figure 8 (AP-PA technique) shows that PTV has been covered with 90%-100% isodose line and this technique has made a better dose uniformity. However, in Figure 7 (single field technique) PTV has been covered with 80%-100% isodose. On the other hand in Figure 7 the 90% isodose line goes across the middle of the tumor; however, in Figure 8 the 90% isodose line covers the PTV completely.

P value for all data is more than 0.05 and just for maximum received skin dose is less than 0.05.



Figure 3: A single field technique (Anterior Posterior) irradiated to gross tumor volume

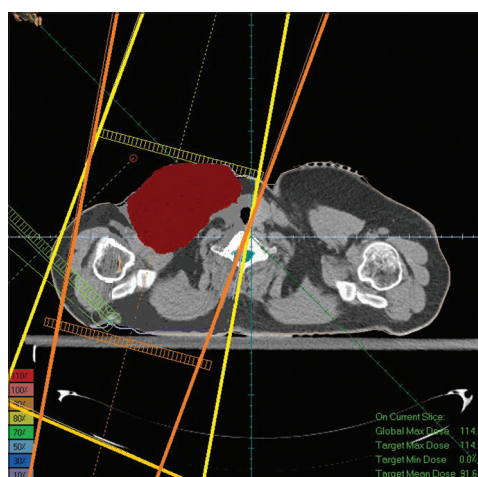


Figure 4: Two parallel opposed fields (Anterior Posterior-Posterior Anterior). Both fields are angled 15° to avoid the irradiation of the spine

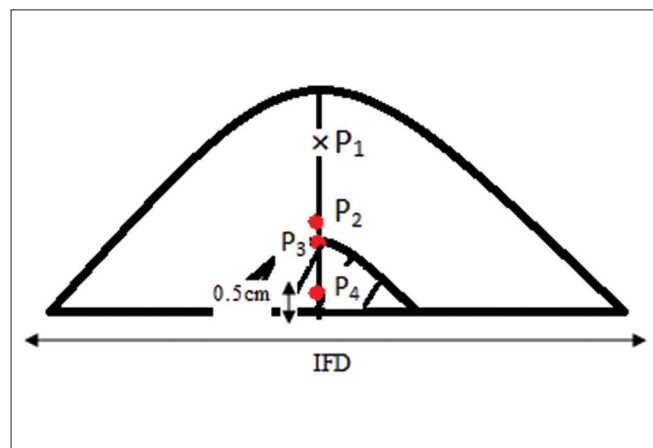


Figure 5: The location of the normalization points P1 is isocenter of the beams. 3 other points are located in the larger depths

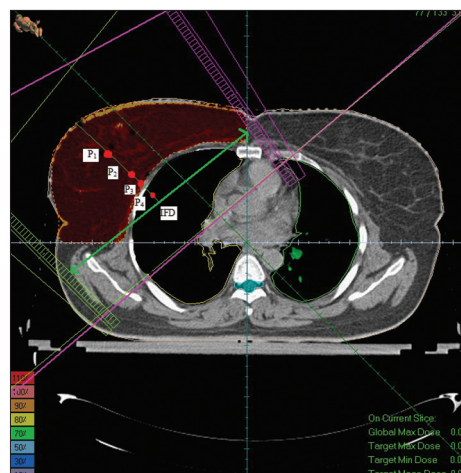


Figure 6: The location of the normalization points

Figures 9-15 illustrates the graphs for all parameters in supraclavicular field techniques. In these figures Technique 1 is a single field, and Technique 2 is AP-PA field.

According to Figure 9, in AP-PA technique the average dose of supraclavicular region is 2.2% more than a single field and

maximum received supraclavicular dose is 1.8% less than a single field.

In AP-PA technique average received breast dose is 0.3% more than a single field and maximum received breast dose is 0.14% less than a single field.

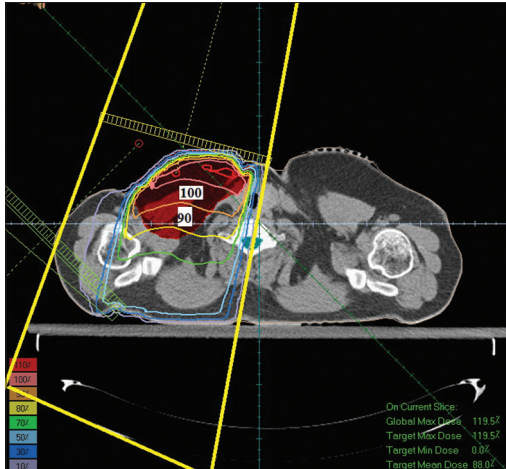


Figure 7: Dose distribution in a single field technique

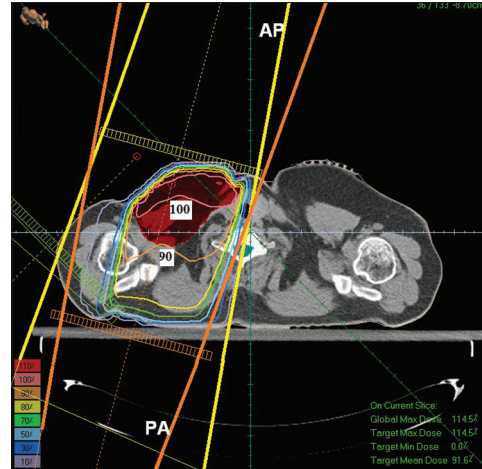


Figure 8: Dose distribution in Anterior Posterior-Posterior Anterior technique

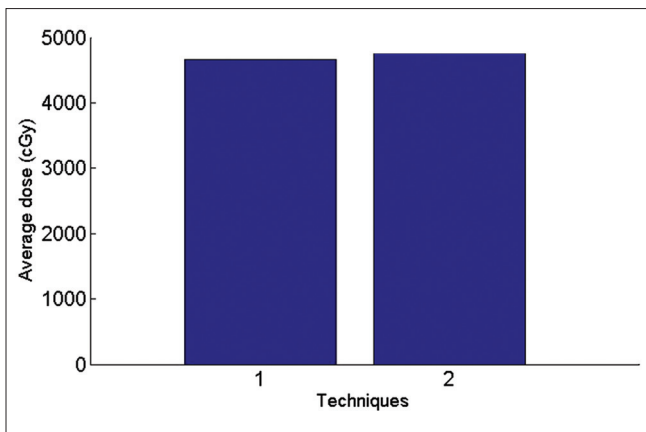


Figure 9: Graph of average received supraclavicular dose in planning tumor volume

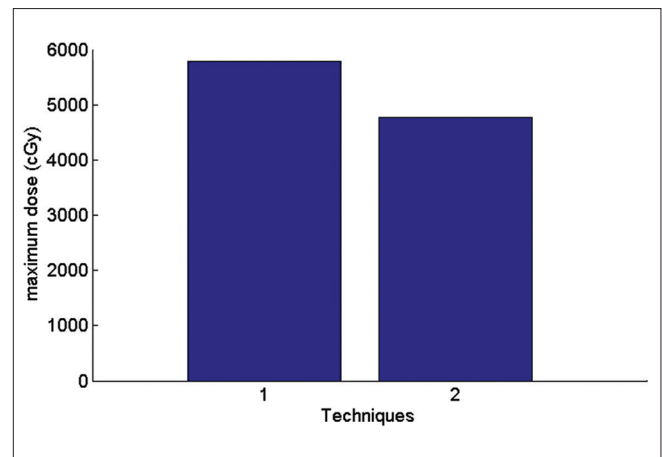


Figure 10: Graph of maximum received heart dose

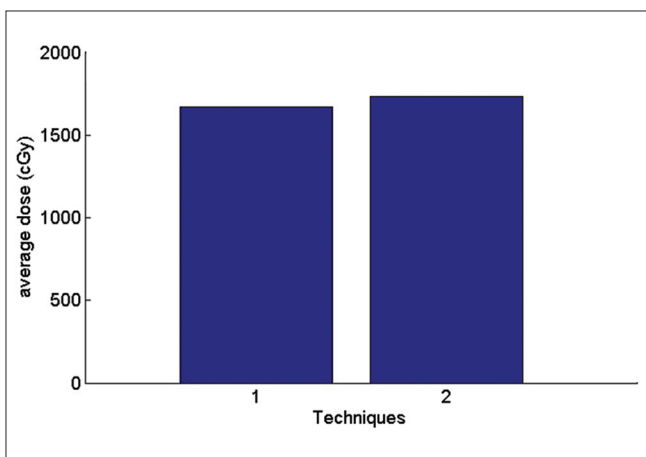


Figure 11: Graph of average received lung dose

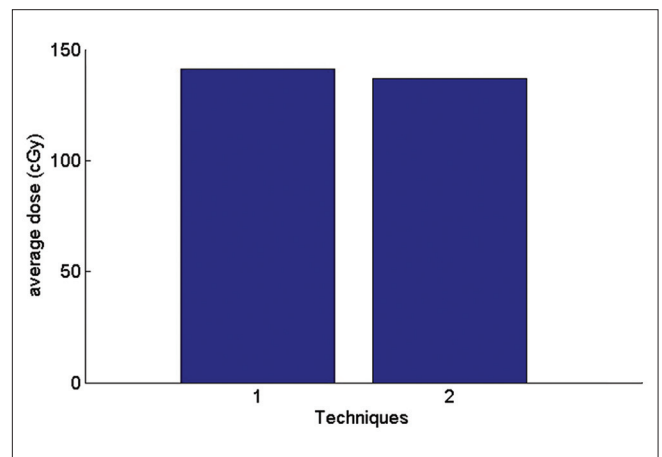


Figure 12: Graph of average received spine dose

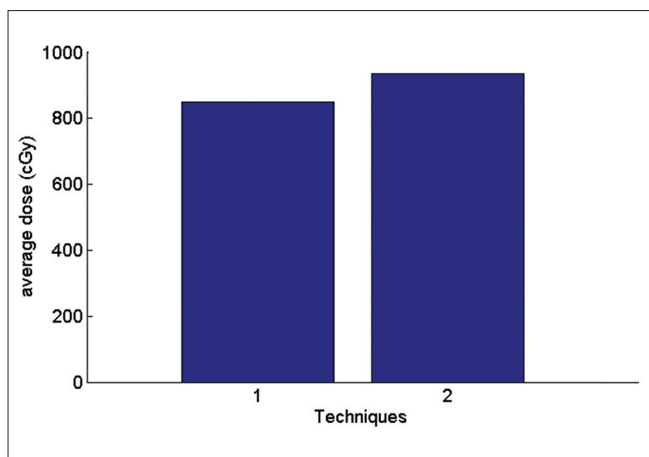


Figure 14: Graph of average received skin dose

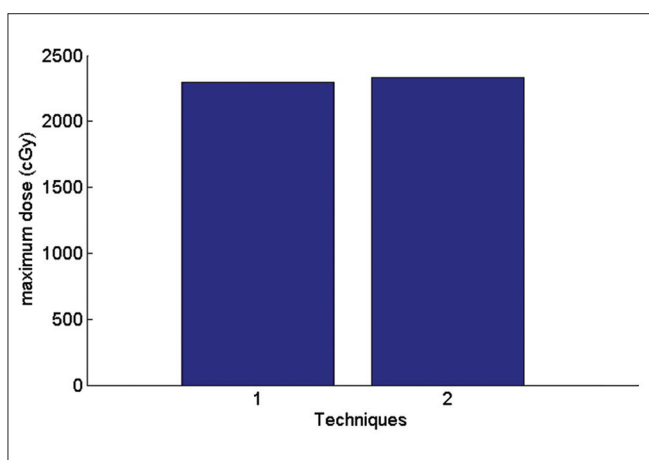


Figure 13: Graph of maximum received spine dose

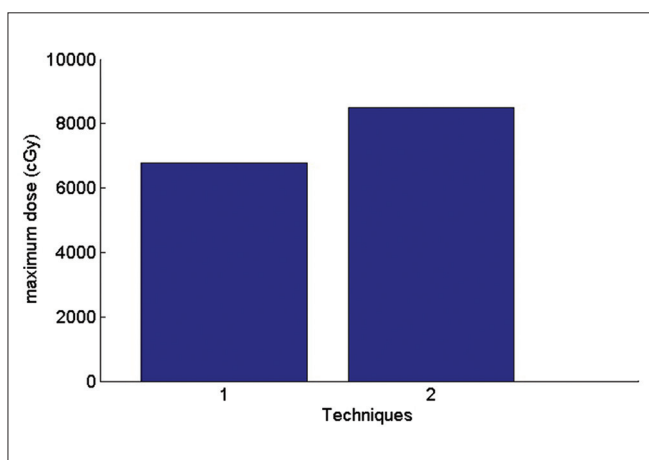


Figure 15: Graph of maximum received skin dose

Coverage of PTV in AP-PA fields is better than a single field. But according to the Figure 11 average received lung dose in AP-PA technique is 4% more than a single field. This is because of the fact that in AP-PA, the isodose curves moves to the larger depths and therefore are more likely to cover the top of the lung.

In AP-PA technique average received heart dose is 0.4% more than a single field and according to the Figure 10; maximum received heart dose is 21.5% less than a single field.

In AP-PA technique, according to the Figure 12 average received spinal dose is 3% less than a single field and maximum received spinal dose according to the Figure 13 is 1.4% more than a single field.

In AP-PA technique, according to the Figure 14 average received skin dose is 9.8% more than a single field and maximum received skin dose according to the Figure 15 is 25% more than a single field.

Therefore, coverage of PTV in AP-PA technique is better than a single field and maximum received heart dose and average received spinal dose decrease but average and maximum received skin and lung dose increase.

In optimizing of tangential fields, the results are illustrated in Figures 16-20. The number of tangential techniques is named as.

Technique 1: Isocenter. Technique 2: Middle of the thickest part of breast (IFD). Technique 3: Border between the lung and chest wall Technique 4: physician’s choice Technique 5: between IFD and isocenter.

In optimization of tangential field all methods cover PTV very similarly and these methods do not have a big difference.

According to the Figure 16 the average received PTV dose in comparisons of physician’s choice method has increased 0.3% in technique 1, 1.4% in technique 2, 0.3% in technique 3. In technique 5 the average received PTV dose has decreased 3.1% in comparisons of physician’s choice. The highest dose is related to technique 2 and this is a reasonable result since point 2 has the largest depth. This fact also shows in the maximum dose. For Maximum received a dose of PTV the second method in which the normalization point is in the middle of the IFD has the largest amount compare to other methods.

So in the second method coverage of PTV is better in comparison to other methods. In First and third method, coverage of PTV are similar in comparison of other methods and physician’s choice method. In Fifth method, coverage of PTV is less in comparison of other methods and physician’s choice method.

According to the Figure 17 average received heart dose in comparisons of physician’s choice method has decreased 0.6% in technique1 2.9% in technique3 1.6% in technique 5. In the second method, the dose has increased 5.4%. So in

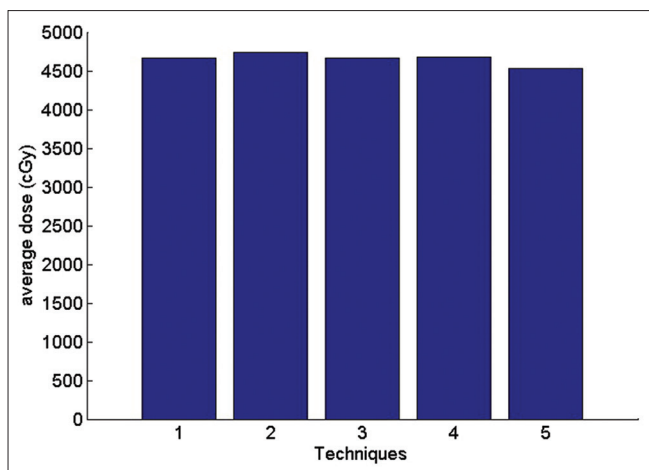


Figure 16: The average received breast dose

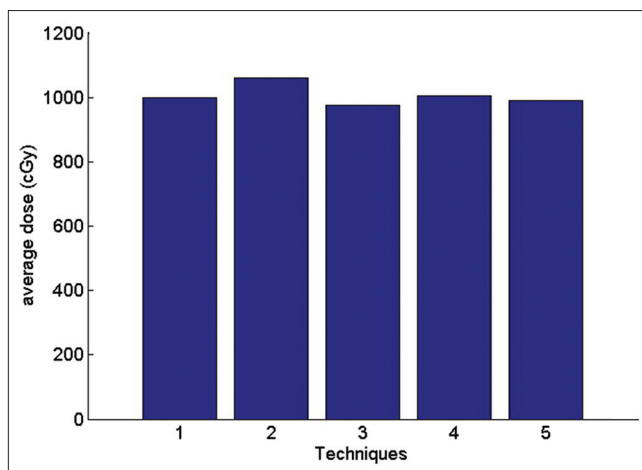


Figure 17: The average received heart dose

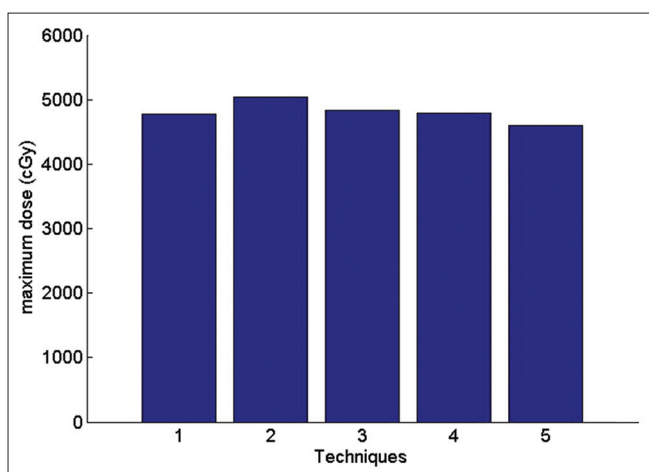


Figure 18: The maximum received heart dose

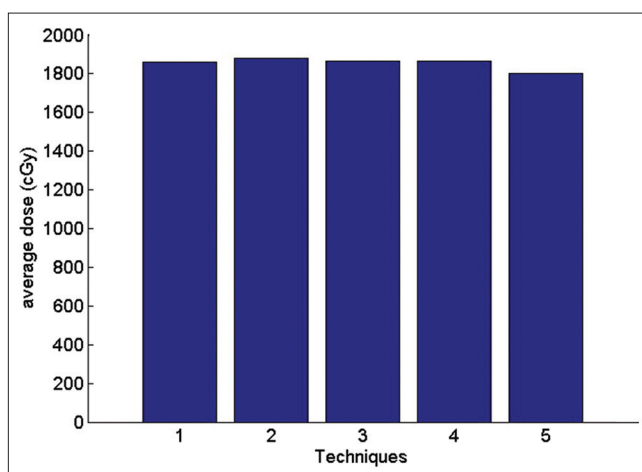


Figure 19: The average received lung dose

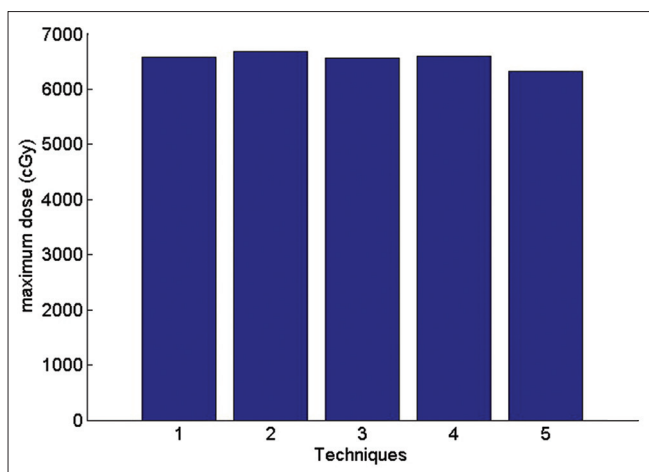


Figure 20: The maximum received lung dose

the other side the technique 2 has the maximum average dose to the heart. The same fact is illustrated for lung dose as Figures 19 and 20.

In this project, the V_{20} parameter is also evaluated. V_{20} is the

percentage of lung volume that has received a dose of 20 Gy and more. V_{20} parameter in comparisons of physician's choice method is similar to technique 1 and it is decreased 0.7% in technique 3 and it is increased 1.6% in technique 2 and 0.3% in technique 5.

Therefore, all methods are similar in comparison of physician's choice method. Each method has special advantages and disadvantages. If it is important for the physician to reduce the dose received by the lung and heart, fifth method can be an optimized method since in this method average and maximum received dose to heart and lung have been reduced few percent in comparisons of physician's choice method and three other methods.

If a better coverage of PTV is important for the physician technique 2 selected. In this method average and maximum received dose to PTV have been increased few percent in comparisons of three other methods. However, in this method we have an increased average and maximum dose of the heart and lung and V_{20} .

CONCLUSION

In this paper, a comparison was done between various tangential and supraclavicular fields techniques.

In supraclavicular field AP-PA technique due to a better coverage of PTV is suggested rather than a single AP. However, in this technique, the average and maximum received lung and skin dose is increased few percent.

In optimizing of tangential field with comparison five techniques with many normalization points were evaluated. If it is important for the physician to reduce the dose received by the lung and heart, the Technique in which the normalization point is located between isocenter and IFD can be selected. In this method average and maximum received dose to heart and lung have been reduced few percent in comparisons three other methods with other depths of normalization points.

If a better coverage of PTV is important for the physician technique that normalization point is located middle of the thickest part of breast or middle of IFD can be chosen. In this method, the average and maximum received dose to PTV have been increased compared with other methods. However, in this method there is increased average and maximum dose for heart and lung and V_{20} . In final, optimizing of tangential showed that each method have spatial advantages and disadvantages.

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