External radiotherapy of intact breast: A comparison between 2D (single CT- slice) and 3D (full CT-slices) plans

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Background: Tangential irradiation of intact breast is one of the most common procedures performed in any radiotherapy center. This method is performed by using 2D and 3D treatment planning. The aim of this study was to compare 2D with 3D plans in breast conserving radiotherapy. Homogeneity of isodose, and lung received dose were compared. **Materials and Methods:** Twenty patients with breast cancer undergoing lumpectomy were included in this study. Two dosimetry plans were generated for each patient. The first plan was performed on one CT-slice (central) by using Eclipse-TPS. The second plan was based on full CT-slices using the same TPS. For both plans, the volumes receiving lower than 95% (cold areas), greater than 105% (hot areas) of the reference dose and the volume of lung receiving ≥30Gy (Vol≥30Gy) were derived from dose volume histogram (DVH). All calculations were done for 6MV photon beams. **Results:** By the 2D plans, the mean values of cold and hot areas were 26.4% and 8.1%, respectively. These values were reduced to 18.9% and 6.9% in 3D plans, respectively (p<0.000, p<0.01). Dose homogeneity was obtained 65.4% in the 2D and improved to 74.8% in the 3D plans (P<0.000). By the use of 3D plans, received dose within lung volume was decreased to 6.7% as compared with 8.9% of 2D plans (P<0.01). **Conclusion:** Application of 3D plans can lead to a more tumor control probability and cosmetic results, but less skin and lung side effects in patients with conserved breast. *Iran. J. Radiat. Res., 2011; 9(2): 121-125*

Keywords: Breast conserving radiotherapy, 2D plan, 3D plan, 6MV photons.

INTRODUCTION

Breast cancer is one of the most common malignancies in women. This disease is the single most common cause of death among women aged between 40 and 50 years. Every year about 1 million new cases are increased to numbers of patients in the world [1]. Nowadays, with advances in imaging instruments and public awareness, cancer of breast can be detected at the stages of I and II. The combination of conservative surgery and radiotherapy is often a suitable option for treatment of patients with an earlier stage invasive breast cancer [2]. As a result, external radiotherapy of the breast is one of the most common procedures performed in any radiation therapy center. The tangential parallel-opposed pair technique is usually applied for this endeavor. This technique is often performed by 2D and 3D treatment planning [3].

The 2D plans are performed by two methods; CT- images and a breast manual contour. In most of the centers that do not have enough CT scan, 2D plans are performed by the use of breast manual contour. In this study, 2D plans were based on CT-image; because, in CT-based plans, dose distribution was calculated with lung correction. In the 2D plans, dose distributions were calculated only on the central single slice or the central breast contour. However, in 3D treatment planning, all dose distributions are calculated on the full CT-slices. One of the important purposes in breast tangential irradiation is to achieve dose homogeneity inside the target volume. Homogeneity of isodose is the main contributing factor responsible for poor cosmetic [4]. The aim of this study was to compare 2D treatment planning (CT-based plans) with

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3D treatment planning in breast conserving tangential radiotherapy. In this comparison, homogeneity of isodose (in breast volume) and lung received dose were considered. All plans were performed with 6MV photons [5].

MATERIALS AND METHODS

Patient selection

The data used in this study were collected at Imam Hossein hospital in Tehran from October 2008 to April 2009. A total of 20 patients with early-stage breast cancer were comprised in this study that underwent radiotherapy after breast-conserving surgery. Six of them had right breast cancer and the other 14 patients had left breast cancer.

Patient CT data

Patients were simulated with the use of Siemens CT-simulator system. The CT-slices were taken at distances of 0.5 cm. At first, an angled board (An angled sponge wedge with leather cover) was placed on top of the CT-simulator table under the patient's head. Then the patients were positioned supine on the board. Ipsilateral arm was positioned above the patient's head to be placed outside of the radiation field. Inferior and superior treatment borders were determined respectively at 2 cm inferior to the inframammary fold and 2 cm beyond the palpable breast tissue. The lateral and medial borders were determined at the midaxillary line and at the midsternal line [6]. Lead wires were placed on the superior, inferior, medial and lateral borders. No auxiliary, supraclavicular or internal mammary lymph node portals were applied in these cases, nor were tangential fields altered to cover these lymph node areas. After CT scanning, the CT data sets were transferred to Eclipse treatment planning system [7] through DICOM network for next process.

Two-D treatment planning (single CT- slice plan)

There is a definite height (related to patient's body size) for the breast in the tangential treatment planning. This height includes of all CT-slices. In 2-D treatment planning based on CD-images, one central-slice of the CT is usually used and planning target volume (PTV) is only delineated on the same slice. However, the lateral and medial fields are covered the whole breast height and the plan is performed. In other word, the whole breast volume is used in 2-D planning (the TPS generalizes result of central slice to the other slices).

Two-D treatment planning was performed by using one central-slice of CT with the Eclipse treatment planning system for each patient. According to other studies [8], it has been difficult to distinguish breast tissue from the surrounding subsliceaneous fat even with verification in the CT window. To avoid the uncertainty and complexity associated with dose calculation in the build-up region, about 0.5 cm from the superficial tissue of the breast was excluded from contouring of the PTV. Furthermore, the lung tissue and 0.5 cm of the breast tissue neighbouring to the deep edge of the fields were also excluded from the PTV and the decreased PTV, was defined (figure 1). The ipsilateral lung was also contoured in the central slice as an organ at risk. The plans were based on the 3D algorithm. In the Eclipse TPS, the equivalent Pencil Beam Algorithm was applied for inhomogeneity correction.
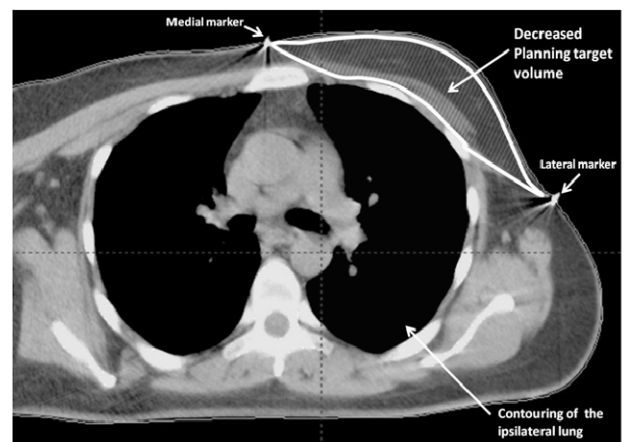

Figure 1. Definition of the planning target volume (PTV) in Eclipse 3D-TPS.

Medial and lateral tangential fields were used for planning. Medial and lateral wedges were used to obtain a more uniform dose distribution [9].

The prescribed dose was 50 Gy in 25 fractions, or its nearest equivalent to the whole breast. No boost dose was applied to the tumor bed [5]. The center of the treated volume was chosen to be the normalization point and receive 100% of the prescribed dose. All patients were treated with 6-MV linear accelerator. With the use of dose volume histogram, the volumes receiving lower than 90% (Vol<90%), lower than 95% (Vol<95%) of the reference dose (cold area), and the volumes receiving greater than 105% (Vol>105%), greater than 110% (Vol>110%) of the reference dose (hot area), were determined. In addition, the volume of ipsilateral lung receiving ≥ 30 Gy (Vol ≥ 30Gy) was derived from DVH [12]. For calculation of dose homogeneity in PTV, we used dose homogeneity index (DHI), which was defined by the following equation [3]:
DHI = 100 – (Vol>105 + Vol<95)

Three-D treatment planning (full CT-slices) plan

In this process, each patient was replanned. The situations (beam energy, angels of fields, used wedges, described dose, used fraction, PTV of central slice) were similar to above, but dose calculations were performed using full CT-slice existed in the whole breast height. Irradiated fields were covered the whole breast height. The planning was performed based on the 3D algorithm in the Eclipse treatment planning system. Vol<90%, Vol<95%, Vol>105%, Vol>110% of the reference dose and Vol≥30Gy were derived from DVH. Then, DHI was similarly defined.

Statistical analysis

To compare DVH values in these two radiotherapy plans, the mean values were analyzed with the use of student *t-test* and differences were studied statistically significant at *p* value of ≤ 0.05.

RESULTS

The results derived from two plans (2D and 3D treatment planning) were compared:

Volume receiving dose <90%

The percentage of the breast volume receiving dose lower than 90% of the described dose ranged between 7.5–37.2%, with a mean value of 19.8% when 2D plans were considered. This volume was reduced when 3D plans were used (mean value 13.2%). This difference was associated with a $p < 0.002$.

Volume receiving dose <95%

The percentage of the breast volume receiving dose lower than 95% of the reference dose limited between 12.2–45.3% (the mean value of 26.48%) in 2D plans. These values were reduced when 3D plan was used and ranged between 8.9–22% with a mean value of 18.92% ($p < 0.000$).

Volume receiving dose >105%

A proportion of the breast volume receiving dose ≥ 105% of the described dose was between 0-28% (the mean value of 8.09%) when 2D plans are examined. The corresponding values for 3D plans were lower and ranged between 0-24% with a mean value of 6.25% ($p<0.01$).

Volume receiving dose >110%

The mean value of the breast volumes receiving dose ≥ 110% of the described dose was 0.86% when 2D plans are examined. This value was 0.61% for 3D plans. These results indicate statistically not significant difference between two plans ($p <0.22$).

Dose homogeneity index (DHI)

The dose homogeneity across the breast volume was improved by the use of 3D plans. About 74.83% of the breast volume received doses between 95–105% of the described dose when 3D plans were used, while by using 2D plan, 59.7-77.8% (the mean value of 65.43%) of the irradiated

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volume received doses between 95–105% of the described dose (*p<0.000*).

Volume of ipsilateral lung receiving dose≥ 30 Gy

The percentage of the ipsilateral lung volume receiving dose greater than 30Gy ranged between 2.44–22.2%, with a mean value of 8.95% when 2D plan was used. This value for 3D plans was lower (mean value 6.73%). This difference was associated with a $p < 0.01$. The results are summarized in table 1 and figure 2.

DISCUSSION

Our results indicated that 2D plan (single-slice CT) could cause more cold area in treated volume as compared with 3D plan (full-slices CT). The existence of cold areas within the treated volume causes reduction of tumor control probability. The amount of this effect depends on the magnitude of microscopic and macroscopic residual

disease. Retrospective studies explain that reduction in breast dose from 50Gy to 45Gy can lead to reduction in local control from 95% to 85% [2]. On the other hand, treatment plans optimized using 2D plans can cause more hot volumes. Hot areas in treated volume are shown to have a worse cosmetic result. Generally, cold or hot volumes in the treated volume of breast cause more heterogeneity in dose distribution. The comparison of two methods with the regard of dose heterogeneity in breast volume, demonstrated that homogeneity in patients who were undergone 3D plans, was improved as compared with 2D plans. So dose heterogeneity may be responsible for worse cosmetic result and late fibrosis of the breast [11].

Improvement of dose homogeneity leads to more tumor control probability with less skin and lung side effects. According to our study about the lung, the mean lung received dose ≥30Gy has considerable difference when 3D plans were considered

Table1. Comparing the results of two treatment plannings: 2D (single-slice) and 3D (full-slice) plans.

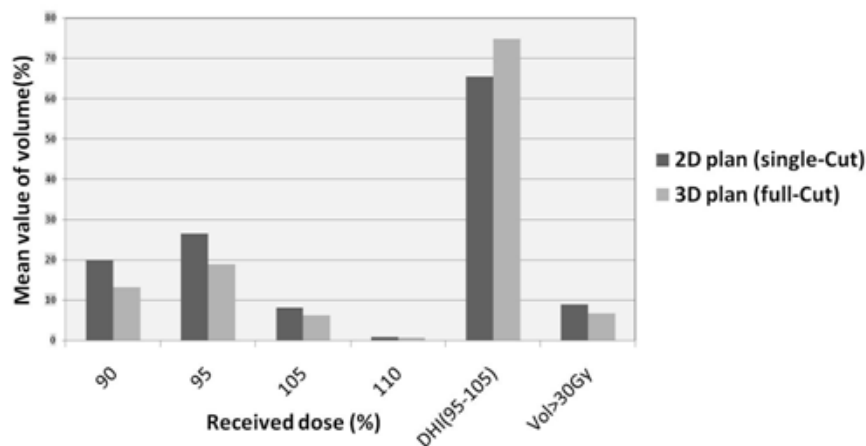| Received dose(Mean)%	2D plan (single-slice)	3D plan (full-slices)	P-value
Vol <90%; range, mean	7.5-37.2%, 19.8%	3.9-15.6%, 13.2%	< 0.002
Vol <95%; range, mean	12.2-45.3%, 26.48%	8.9-22%, 18.92%	< 0.000
Vol >105%; range, mean	0-28%, 8.09%	0-24%, 6.25%	<0.01
Vol >110%; range, mean	0-5.7%, 0.86%	0-1.8%, 0.61%	<0.22
DHI (95-105)%; range, mean	59.7-77.8%, 65.43%	67-86.3%, 74.83%	<0.000
Vol ≥30Gy; range, mean	2.44-22.2%, 8.95%	1.91-15.1%, 6.73%	<0.01

Figure 2. Comparison of two treatment plannings: 2D (single-slice) and 3D (full-slices) plans.

as compared with 2D treatment planning. The study results have been in agreement with the results of other series that demonstrated that 3D treatment planning was a more suitable option for patients with breast cancer treated with conservative surgery. Vincent *et al.* in their study have demonstrated the need for 3D planning in radiotherapy of intact breast [12]. Shouman *et al.* indicated improvement of dose homogeneity in 3D plans as compared with 2D [13]. Neal *et al.* showed in their studies the only way to truly appreciate the dose inhomogeneity within the clinical target volume is to devise a 3D plan, perform a 3D dose calculation, and display the result in the form of a dose volume histogram (DVH) [12]. These studies show excellent local control with good cosmetic results in the 3D treatment planning. Consequently, We showed that basing the treatment geometry on a single CT slice through the central axis (2D plan) using even a 3D TPS with a 3D calculation algorithm will lead to more cold and hot volumes in treated volumes as compared with 3D plans. Hence, 3D treatment planning is a more suitable option for patients with breast cancer treated with conserving. Although, such technology may be difficult to implement in a large scale due to logistic and economic considerations [8]. However, currently, breast cancer radiotherapy shifted towards computed tomography (CT)-guided treatment planning has enabled the application of new techniques such as three-dimensional (3D)- conformal radiotherapy (3D-CRT) and intensity modulated radiotherapy (IMRT) [14]. These techniques enable achieving more dose homogeneity as prescribed by ICRU-50 report for tangential fields [15].

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