Intensity Modulated Radiotherapy (IMRT) Versus Dynamic Wedge Techniques in Radiation Therapy of the Breast; Impact on Dosimetric Parameters and Radiation dose to Contralateral Breast

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Abstract

Background: New techniques of radiation therapy are being introduced in the management of breast cancer. One of the most rapidly emerging new techniques is intensity modulated radiotherapy (IMRT).

Aim of the Study: The purpose of the study is to compare between two different techniques of radiation therapy of breast cancer for intact breasts after breast conservative therapy (BCT); IMRT and dynamic wedge (DW) (standard technique) regarding their impact on dosimetric features of the treated breast and the radiation dose received by the contralateral breast.

Patients and Methods: Fourteen female patients with breast cancer treated with BCT and referred for adjuvant radiation therapy at radiation therapy department of King Abdulaziz University Hospital; Jeddah Saudi Arabia during the period January 2007-August 2007 had been studied. Their archived CT scans for breasts were retrieved and the two plans (IMRT and dynamic wedge techniques) were implemented in those CT cuts. The dosimetric parameters (maximum dose; minimum dose, mean dose and homogeneity index) for the treated breast as well as the radiation dose received by the other breast (at 5%, 50% and 95% of its volume) were compared between the two techniques.

Results: Fourteen patients had been included in the study; their mean age was 44.9 years; 8 were left sided, and 6 right sided and all of them had been referred for radiation therapy after BCT. The mean radiation dose received by DW technique was 50.68 Gy as compared to 51.23 by IMRT (p value: 0.023), the mean homogeneity index (HI) of dynamic wedge technique was 15.36 (± 39 SD) as compared to 7.02 for IMRT (p value 0.001).

Regarding the radiation therapy dose received by the contralateral breast; it had been found that in DW technique; the 5%; 50% and 95% of the volume of the contralateral breast received a mean radiation dose of 1.16 Gy, 0.31 Gy, and 0.097 Gy respectively as compared to 4.11 Gy, 1.33 Gy and 0.82 Gy respectively; a highly significant difference (p value: 0.0001) with significantly higher dose to contralateral breast by IMRT technique as compared to DW technique.

Conclusion: Although the IMRT technique achieved a better dose homogeneity as compared to dynamic wedge technique; however, the radiation dose received by the contralateral (normal) breast was significantly higher in IMRT technique. So we have to be cautious if we want to implement the IMRT technique in radiation therapy of breast to avoid unnecessary radiation exposure to the contralateral breast with its possible impact on late incidence of carcinogenesis.

Key Words: Breast cancer – Contralateral breast – IMRT – Dynamic wedge.

Introduction

As more women choose breast conservation therapy (BCT), breast radiation therapy is a large component of a radiation oncology practice. The advances in radiation technology have made standard radiotherapy much more precise [1,2]. Until recently, the total time and dose of standard radiation had not significantly changed in over 20 years with the exception of a possible 10 to 16 Gy electron boost to the surgical cavity [3,4].

Computerized tomography (CT) based treatment planning in conjunction with new capabilities of the linear accelerator has revolutionized radiotherapy for breast cancer. Targets and avoidance structures can be easily defined on axial imaging. The goal of treatment planning software algorithms is to produce discriminating radiation fields that conform to the breast, chest wall and/or regional nodes to achieve a homogenous dose to the breast and decrease or avoid dose to the ribs, lung and the heart. This technology allows us to adapt the treatment to fit the variety of breast and chest wall shapes [5].

The investigation and clinical application of intensity modulated radiotherapy (IMRT) for ad-
juvant treatment of breast cancer has been the subject of increasing study in recent years [6].

Most planning studies have shown that IMRT is superior to 3 dimensional conformal radiotherapy (3D-CRT) in treating target volume adequately while sparing healthy organs and tissues [7-10].

There is a critical point in the evaluation of quality of planning techniques; radiation dose homogeneity within the planning target volume (PTV) and this is evaluated by homogeneity index (HI) [9].

The aim of the current study is to evaluate the difference between two techniques of radiation therapy in the intact breast; IMRT and dynamic wedge regarding two points: radiation dose homogeneity within the planning target volume (HI) and radiation dose delivered to the contralateral breast.

Patients and Methods

This is a study was done on archived CT scans for female patients with breast carcinoma who were treated with BCT and referred for adjuvant radiation therapy at radiation therapy department of King Abdulaziz University hospital; Jeddah Saudi Arabia during the period January 2007-August 2007 (inclusive). All patients should have been treated on BCT basis and 2 field's treatment (no supraclavicular filed).

A total number of fourteen patients’ CTs were retrieved. The technique of doing CT scan for those patients was that: patients were located in supine position; CT cuts started at the mandible and extended several centimeters below the inframammary fold at 3 mms difference. After retrieval of these CT cuts; the IMRT planning (inverse planning technique) would include the following structures to be contoured in the IMRT planning system (Kon Rad-V.2.2.23); the planning target volume (PTV) which consisted of the ipsilateral breast defined as the soft tissue volume of the breast; excluding the lung and bony structures; that would be irradiated by dynamic wedge technique, also; the ipsilateral lung; heart and contralateral lung and breast. The treatment fields in IMRT were done as 6 equally spaced non-coplanar fields around each patient in the axial plan (Fig. 1). Radiation dose prescription was as follows; a total dose of 50 Gy over 25 fractions over 5 weeks (2 Gy per fraction) was prescribed at PTV with dose constraints that followed these principles: 95% isodose surface should cover 100% of PTV; the maximum dose should not exceed 110% of the prescribed dose, limitations to normal tissues were controlled using the radiation therapy oncology group (RTOG) criteria (Table 1) [14,15]. For dynamic wedge fields planning way; we used the standard forward planning technique using the planning CT software (Eclipse 8.1) whereby we plan the fields on the breast target (PTV) using tangential fields covering the PTV as well a margin of 2 cms in the inframammary fold and 1.5-2 cm form the ipsilateral lung and the anterior field border will be in the fall off. Lateral wedges were used to improve the dose inhomogeniety. Radiation dose was prescribed as 50 Gy over 25 fractions over 5 weeks at breast isocenter (usually located in the center of the breast) (Fig. 2).

The homogeneity index (HI) defined as: D2-D98/PD X 100 [9] was evaluated and compared between the two radiation techniques.

Whereby D2 is radiation dose received by 2% of PTV (represented the maximum dose).

D98 is radiation dose received by 98% of PTV (represented the minimum dose).

PD prescribed dose.
Table (1): Dose limitations for normal tissues in IMRT planning technique.

<table>
<thead>
<tr>
<th>Organ name</th>
<th>Dose limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contra lateral breast</td>
<td>&lt;3% of PD at any point</td>
</tr>
<tr>
<td>Ipsilateral lung</td>
<td>&lt;15% of the lung can receive 30% of PD</td>
</tr>
<tr>
<td>Contra lateral lung</td>
<td>&lt;15% of the lung can receive 5% of PD</td>
</tr>
<tr>
<td>Heart (left sided lesions)</td>
<td>&lt;5% of the heart should receive &lt;40% of PD</td>
</tr>
<tr>
<td>Heart (right sided lesions)</td>
<td>&lt;5% of the heart should receive &lt;5% of PD</td>
</tr>
</tbody>
</table>

PD: Prescribed dose.

The radiation dose received by 55; 50% and 95% of the contralateral breast was evaluated and the two techniques were compared.

Statistical comparison between the two techniques was done using the SPSS software.

Results

Fourteen female patients with breast cancer had been studied. Their mean age was 44.93 years (±7.8 years SD). Eight patients (57.1%) had left sided lesions; while 6 (42.9%) had right sided lesions. Regarding stage at presentation; the majority (7 patients; 50%) were T1, then T2 (6 patients; 42.9%) and the minority were T3 (1 patient; 7.1%). Lymph node involvement was seen 5 patients only (35.7%); while the majority (64.3%) was No. All these patients were treated with BCT whereby they had lumpectomy and axillary lymph node resection followed by chemotherapy (4 cycles of AC; Adriamycin, cyclophosphamide) followed by radiation therapy.

The study is a retrospective one whereby the CT scans done for those patients had been retrieved and two different plans (WD and IMRT) were applied and studied.

Table (2), shows the dosimetric features of the two techniques in the treated breast.

Table (3) shows the radiation dose received by the contralateral (normal) breast by the two techniques.

The same findings can be seen in the dose distribution of 5 Gy isodose line difference between the 2 techniques (Figs. 5,6); where we can see clearly that the 5 Gy line in IMRT represented a bigger area in the contralateral breast in IMRT dose distribution compared to that for DW technique.

From Table (2); it can be seen clearly that; the homogeneity index (HI) is far more better (7.02) in IMRT technique as compared to that of DW technique (15.26) and the difference was statistically highly significant (p value <0.001); which means that; IMRT as a technique gives a more homogeneous dose distribution of the treated breast as compared to DW technique.

However; on looking to Table (3) whereby a comparison between radiation dose delivered by IMRT versus DW to the contralateral (normal) breast; at different volumes (5%; 50% and 95%); there was a great difference in dose delivered between both techniques to the normal breast; at the 3 levels of volumes (5%; 50% and 95%); but in this situation; it is in favor of the DW technique which achieved a statistically significant lower dose to the contralateral breast (p value <0.0001).

Table (2): Dosimetric features of the two techniques in the treated breast.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Maximum dose</th>
<th>Minimum dose</th>
<th>Mean dose</th>
<th>HI</th>
</tr>
</thead>
<tbody>
<tr>
<td>DW</td>
<td>53.37 Gy</td>
<td>43.87 Gy</td>
<td>50.68 Gy</td>
<td>15.36</td>
</tr>
<tr>
<td>IMRT</td>
<td>54.75 Gy</td>
<td>47.76 Gy</td>
<td>51.29 Gy</td>
<td>7.02</td>
</tr>
<tr>
<td>p value</td>
<td>0.0001</td>
<td>0.044</td>
<td>0.021 Gy</td>
<td>0.001</td>
</tr>
</tbody>
</table>

DW: Dynamic wedge technique.
IMRT: Intensity modulated radiotherapy technique.
HI: Homogeneity index.
Gy: Gray.

Table (3): Radiation dose received by the contralateral (normal) breast by the two techniques.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Radiation dose received (mean)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>At 5% of breast volume</td>
</tr>
<tr>
<td>DW</td>
<td>1.16 Gy</td>
</tr>
<tr>
<td>IMRT</td>
<td>4.11 Gy</td>
</tr>
<tr>
<td>p value</td>
<td>0.0001</td>
</tr>
</tbody>
</table>

DW: Dynamic wedge technique.
IMRT: Intensity modulated radiotherapy technique.
Gy: Gray.
Major advances had been achieved during the last decade in the field of radiation therapy. One of the most significant achievements in that field was the introduction of IMRT; which achieved a better radiation dose distribution in the treated targets and minimization of the dose to the critical organs at risk of radiation therapy [16-20].

The aim of the current study was to compare between two techniques of radiation therapy to the breast; the standard technique (DW) and the new technique (IMRT) regarding the radiation dose homogeneity in the treated breast and the radiation dose delivered to the contralateral breast. It was found that the new technique (IMRT) was superior as compared to the standard one (IMRT) regarding radiation dose homogeneity in the treated breast (p value :0.001); however; the IMRT was worse regarding the radiation dose received by the contralateral breast (p value: 0.0001).

In modern radiotherapy era; it not only important to control the disease and achieve a good results in terms of disease free and overall survival; but also; to avoid late radiation effects on normal tissues, especially with advancement in the treatment strategy of cancer now; a higher percentage of cured patients could be achieved; so the impact of late treatment effects (especially carcinogenesis) started to be of concern.

For the above mentioned reasons; we initiated that study that proved although IMRT achieved better dose homogeneity; it delivered higher radiation dose to the contralateral breast. The current study is in agreement with many other studies evaluating the role of IMRT in breast cancer regarding its impact on radiation dose homogeneity like Huanq et al. [21] and Ronqsriyam et al. (2008) [22]; however there was a different conclusion regarding the radiation dose delivered to the contralateral breast; as it was significantly higher in the current study as compared to lower doe delivered by IMRT in the previously mentioned two studies; however; other radiation oncologists like Editha et al. [6] showed similar results to the current study with higher dose to the contralateral breast in IMRT technique as compared to the standard wedge technique. These discrepancies between different findings could be explained by differences in the techniques of IMRT between different studies as in the current study as well that of Editha et al. [6]; we used many radiation fields (6 in the current study and 9 in Editha et al. study); however; Huanq
et al. [21] and Ronqsriyam et al. used smaller number of fields.

So; in conclusion; the use of IMRT in the adjuvant setting of breast cancer should be taken with caution; as different techniques may impose different radiation dose deliveries to the organs at risk or to the contralateral breast. So a bigger number of studies with more mature data may be needed to achieve the best IMRT technique that is the best regarding dose homogeneity in the treated breast and the least radiation dose to the contralateral breast.

References