ABSTRACT

Appropriately delivered post-operative radiotherapy is an integral part in the multidisciplinary approach for the treatment of invasive breast cancer.

The Aim of the Work: Is to find the most effective simple way to achieve homogeneous dose distribution to the junction of the supraclavicular beam and tangential beams, in absence of CT planning facilities, through measurement/calculation of dose using different techniques.

Material and Methods: Alderson human phantom was planned and irradiated through 4 different techniques. Technique I, simple abutment of fields; technique II, table rotation in tangential fields; technique III, table rotation in tangential beams and half beam block in supraclavicular field; and technique IV, simple triangular block in supraclavicular field. Dose to the junctional area was both measured using film dosimetry, and calculated using CT planning (Precise plan).

Results: Simple abutment of fields resulted in a significant junctional overdose in both measured (125%) and calculated (171% to 20% of junctional volume) dose. Best results were seen in technique III (table rotation and half beam block) where the measured dose was 89% and calculated dose was 89% to 20% of junctional volume. Technique II and IV resulted in 120%, 120% measured dose and 128%, 138% calculated dose to 20% of volume of junctional area, respectively.

Conclusion: Table rotation in tangential beams and half beam block in supraclavicular beam seems to be an effective and simple method to prevent junctional overlap in the sitting of post-mastectomy radiotherapy for breast cancer in case of absence of CT-based treatment planning and conformal radiotherapy.

Key Words: Radiotherapy – Postmastectomy – Supraclavicular field – Tangential field.

INTRODUCTION

Radiation therapy (RT) has demonstrated the ability to reduce the risk for loco regional failure [1-6] and to improve the 15-year overall survival in a meta-analysis of data from over 40,000 women with breast cancer [7].

The delineation of RT targets is based on established surgical principles, pathologic findings, and failure patterns, resulting in broad-field irradiation that encompassed the whole breast and/or chest wall with or without regional nodes. This approach is simplistic in design, nevertheless widely adopted due to its success in reducing disease recurrence as well as its ease of implementation [8]. Given the benefits of appropriately administered RT on local recurrence and long-term survival, technical excellence in irradiating the intact breast or the chest wall is critical. The NCCN (National Cancer Comprehensive Network) guidelines [9] recommend the use of CT-based treatment planning to ensure reduced radiation dose to the heart and lungs.

The technique adopted in the department of radiotherapy, National Cancer Institute (NCI), Cairo University, is to irradiate the chest wall and peripheral lymphatics in post-mastectomy RT with the upper border of tangential fields (tangs) set at the sternal angle, which is the same lower border of the supraclavicular (S/C) field. No field matching techniques are done. Subcutaneous fibrosis and apical lung fibrosis as a result of junctional overlap sometimes become clinically manifest. Despite the availability of CT based treatment planning, two dimensional planning using the conventional...
Aim of the Work:

The aim of the present work is to find the most effective simple way to achieve homogeneous dose distribution to the junction between the supraclavicular beam (S/C) and tangential beams (tangs), in absence of CT planning and conformal radiotherapy facilities, through measurement/calculation of the dose to the junction using different techniques.

MATERIAL AND METHODS

Eight random patients who were under treatment with post-mastectomy radiotherapy (PM-RT) were chosen, among whom no special field matching techniques between the tangs and the S/C field were done (simple abutment of fields). Doses to the junction between S/C field and tangs were measured using two diodes placed at the match-line between the two fields. Diodes were placed parallel to the junction line. One diode was placed 1cm lateral to the medial end and the other 1cm medial to the lateral end of the junction line. All patients were irradiated with a 3-field SSD technique (one direct S/C and two wedged tangs) using CO\textsuperscript{60} machine (Fig. 1).

The diode calibration procedure has been done as follows: Readings of the diodes (entrance and exit dose) were converted into dose at the point of d\textsuperscript{max} under the patient surface using the following equation:

\[ D_{\text{diode}} = R_{\text{diode}} \cdot N_D \cdot \Pi_i C_i \]

Where \( R_{\text{diode}} \) was the diode reading, and \( N_D \) was the calibration factor determined under reference circumstances (SSD=100cm, field size 15 x15 cm, phantom thickness 15cm, and temperature 22\(^\circ\)C). The correction factors \( C_i \) were required for irradiations applied in non-reference circumstances and incorporate corrections for field size, SSD, patient thickness, skin temperature, and wedge angle.

According to the results of those readings, the following steps had been undertaken:

Step I: Alderson phantom was planned on the simulator with different techniques.

Technique I (classic): For tangs, the medial border was set at the midline, lateral border at the mid-axillary line, superior border at the sternal angle, and inferior border 16cm below the upper border. Two lead wires were placed in the midline and midaxillary line. The couch and gantry were moved till both wires together with the medial border of the medial tang were overlapped while the SSD was 80 at the center. The center of the field was drawn. The same was applied for the lateral tangential field. The collimator angle was added so that the field borders were made parallel to the chest wall. For the S/C beam, a direct field at SSD 80 with a collimator angle was made so that the caudal border of the S/C abutted the cranial border of the medial tang. The medial border of the S/C field was at the midline, the superior border at the crico-thyroid membrane, and the lateral border covered the axillary fold (Fig. 2).

Technique II (table rotation): The same phantom was planned using the same field borders. The table was rotated in both tangential fields so that the cranial edges of both tangential fields lined-up perfectly with the inferior border of the S/C field. Phantom with a film inserted at the match-line was then irradiated.

Technique III (table rotation +HBB): Both table rotation and half beam block (HBB) were used to eliminate the inferior divergence of the S/C beam into tangential fields so that the central, non-divergent portion of the beam became the inferior border of that field (Fig. 3).

Technique IV (S/C Block): The same technique was used as in Fig1 without the collimator angle in the S/C field. Yet the area of overlap between the medial tang and S/C was blocked with a small triangular block (Fig. 4).

Step II: serial CT cuts were taken using CT simulator. The clinical target volume (CTV) was drawn in each CT cut. 3-D planning using the same previously described techniques was
done and dose to the junction was calculated with each different technique using Precise treatment planning system (TPS) (Fig. 5). The junctional volume was defined as the most caudal CT cut in the S/C CTV and most cranial CT cut in chest wall CTV. The mean dose from both beam groups (tangs and S/C) to the junctional area was calculated as well as the dose delivered to 20% of the volume of the junctional area (V20).

Fig. (1): Two diodes placed at the match-line between tangential fields and S/C field.

Fig. (2): Technique I: Simple abutment of tangential fields with S/C field.

Fig. (3): Technique III, table rotation in tangential fields and half beam block in S/C field.

Fig. (4): Technique IV, triangular block in supraclavicular field with classical tangential fields.
RESULTS

Doses to the junctional area as measured using the two diodes placed over the skin of the junctional area for eight random patients under treatment for PMRT are presented in Table (1). The percentage of the measured dose to the junctional area to the proposed dose ranged from 0 to 47% with a median of 28% and a mean ± SD of 25%±18% overdose over the junctional area.

Doses measured using film dosimetry at the junctional area of Alderson phantom irradiated by different techniques are presented in Table (2). Dose was least with technique III (89% of prescribed dose) and maximum with the classic technique (125% of prescribed dose). Techniques II and IV were similar (120% of prescribed dose).

Mean dose as well as the V20 (% dose to 20% of the volume of the junctional area as derived from DVH) calculated at the junctional volume using different techniques of planning of Alderson phantom are presented in Table (3). V20 is used because the dose to the junctional zone is markedly heterogeneous so the mean dose may not represent the expected overdose. The V20 was highest in the classic technique (171%) and lowest with technique III (89%).

Table (1): Dose to the junctional area as measured by the diodes in 8 patients.

<table>
<thead>
<tr>
<th>No.</th>
<th>Maximum dose measured in cGy by diodes</th>
<th>Proposed dose per fraction in cGy</th>
<th>% overdose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>416.25</td>
<td>267</td>
<td>36</td>
</tr>
<tr>
<td>2</td>
<td>422.00</td>
<td>225</td>
<td>47</td>
</tr>
<tr>
<td>3</td>
<td>354.50</td>
<td>267</td>
<td>25</td>
</tr>
<tr>
<td>4</td>
<td>290.65</td>
<td>200</td>
<td>31</td>
</tr>
<tr>
<td>5</td>
<td>225.00</td>
<td>225</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>374.00</td>
<td>200</td>
<td>46.5</td>
</tr>
<tr>
<td>7</td>
<td>290.00</td>
<td>225</td>
<td>22</td>
</tr>
<tr>
<td>8</td>
<td>267.00</td>
<td>267</td>
<td>0</td>
</tr>
</tbody>
</table>

Table (2): Measured doses, using film dosimetry, to the junction area of the irradiated phantom with different techniques.

<table>
<thead>
<tr>
<th>Technique</th>
<th>Maximum dose measured in cGy</th>
<th>Proposed dose in cGy</th>
<th>Measured/proposed dose %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technique I (classic)</td>
<td>280</td>
<td>225</td>
<td>125</td>
</tr>
<tr>
<td>Technique II (table rotation)</td>
<td>270</td>
<td>225</td>
<td>120</td>
</tr>
<tr>
<td>Technique III (table rotation+HBB)</td>
<td>200</td>
<td>225</td>
<td>89</td>
</tr>
<tr>
<td>Technique IV (small ∆ block)</td>
<td>270</td>
<td>225</td>
<td>120</td>
</tr>
</tbody>
</table>

Fig. (5): Reconstructed images of the phantom after the chest wall (red) and S/C (blue) CTVs as well as organs at risk were drawn. (a) Classical technique (b) Table rotation and HBB.
DISCUSSION

Hot spot caused by divergence of the tangential beams into the S/C field and of the S/C beam into the tangential field can exist just beneath the skin surface at the junction of the inferior border of the S/C field and the superior border of the tangs. The "horns" at the edges of the beam produce marked increase in the dose beneath the match-line if these divergences are not corrected. Despite the shortness of the diodes to measure the actual dose delivered at depth, measurement at the skin of the junction showed that the wide diversity of doses could result in marked dose heterogeneity and possible overdose if simple abutting of the fields is done. This was confirmed by film measurement using Alderson phantom which showed higher doses at depth. Use of CT-based treatment planning to ensure homogenous dose distribution to CTV is considered the most acceptable solution. Use of mono-isocenter for both tangs and S/C with half beam block and conformal radiotherapy will minimize the junctional overlap. However, in absence of facilities of CT planning, or if the department workload cannot allow CT-based planning for every patient, simple techniques may be used. The divergence of the tangential fields can be eliminated by angling the foot of the treatment couch away from the radiation source to direct the tangential beams inferiorly so that the superior edges of these beams line up perfectly with the inferior border of the S/C field (table rotation). The inferior divergence of the S/C beam can be eliminated by blocking off the inferior half of this beam so that the central non-divergent portion of the beam becomes the inferior border of this field (half beam block). Use of both table rotation in tangential beams and half beam block in the S/C beam seems to be the best way to eliminate the junctional overlap supported by both film measurement and dose calculation in the phantom. Use of table rotation alone seems to decrease the dose to the junction. Also, use of small block at the caudal end of the S/C field is less effective, however it seems more efficient than simple abutment of fields.

Conclusion:

In the sitting of post-mastectomy radiotherapy, in absence of facilities of conformal radiotherapy, simple abutment of the tangential fields and supraclavicular field results in significant junctional overdose. Using table rotation in tangential fields and half beam block in the supraclavicular field can result in more homogenous dose distribution to the junctional area.

REFERENCES


