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Chapter 8

Implementation of a forearm support to reduce the amount of irradiated lung and heart in radiation therapy of the breast

Coen W. Hurkmans¹
Jacques H. Borger¹
Aline v. Giersbergen¹
B.C. John Cho²
Ben J. Mijnheer¹

¹The Netherlands Cancer Institute/Antoni van Leeuwenhoek Huis
Department of Radiotherapy, Plesmanlaan 121
1066 CX Amsterdam
The Netherlands

²The Cross Cancer Institute
Department of Radiation Oncology, 11560 University Ave
T6G 1Z2, Edmonton, Alberta
Canada

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Abstract

We compared simulator images of medial tangential fields taken in two positions: (1) with the ipsilateral arm abducted, holding a 'L-bar' armrest and (2) with both arms extended above the head in a forearm support. The average maximum heart distance as well as the central lung distance decreased significantly, by 3.4 (SE = 0.9) and 4.7 (SE = 1.1) mm, respectively, when the new forearm support was used. The estimated normal tissue complication probability for excess cardiac mortality decreased with on average 3.1% (SE = 1.3%). For some patients, a greater amount of the axilla was included in the field. We recommend the use of the forearm support during breast cancer treatment with tangential fields to decrease the amount of heart and lung inside the fields.

Introduction

In many institutions, a 'L-bar' armrest is used to position the ipsilateral arm during breast cancer irradiation, typically with tangential fields. The amount of heart and lung tissue inside these treatment fields can be substantial and clinically relevant [5,8]. It is known that the shape of the breast and thorax is influenced by the position of the arm e.g., [4].

However, little is known about the influence of the arm position on the amount of heart and lung inside the tangential treatment fields. In an interesting study, Canney et al showed that the use of a breast board in combination with a 'T-grip' placed above the head resulted in a reduction of the mean cardiac dose of 60% (p<0.001) for left sided breast cancer patients [2]. The aim of this work is to quantify the amount of the heart and lungs inside tangential treatment fields using a 'L-bar' armrest compared to a forearm support positioned above the head, without the use of a breast board. Data for 12 left-sided breast cancer patients lying in supine position with the arm in the 'L-bar' armrest and in the forearm support were analysed.

Methods and materials

Breast treatment was simulated for 12 randomly selected left-sided breast cancer patients in supine position. Firstly, the patient was positioned using the 'L-bar' armrest (Figure 1a). A radiation oncologist placed a lead wire around the palpable breast tissue. The simulator isocentre was placed
Forearm support versus ‘L-bar’ support

at the middle of the sternum. Using fluoroscopy, the gantry angle was rotated such that the medial and lateral projections of the lead wire overlapped. A simulator image was then taken (Figure 2). Secondly, the patient was positioned with both arms in a forearm support (Posirest from Sinmed BV, Reeuwijk, The Netherlands) above the head (Figure 1b). The radiation oncologist verified the lead wire still outlined the palpable breast tissue. If not, the lead wire was adjusted to the appropriate position. A second simulator image was then taken using the same procedure as described above. Treatment fields were delineated on the simulator images using a margin of 15 mm between the lead wire and the field border. The central lung distance (CLD), defined as the distance from the dorsal field edge to the thoracic wall measured in the central axial plane [1], was measured in the simulator images. In addition, the maximum heart distance (MHD), defined as the maximum distance of the heart contour, as seen in the beam’s-eye view of the medial tangential field, to the medial field edge [5], was also measured in these images. The measurements were corrected for the difference in magnification of the CLD and MHD in our images, collected with the beam isocentre at the sternum, compared to the magnification used in the definitions of the CLD and MHD, where the images were collected with the beam isocentre in the middle of the breast.

Table 1. Measured central lung distance (CLD), maximum heart distance (MHD) and estimated NTCP for excess cardiac mortality in tangential field breast irradiation using a ‘L-bar’ armrest or a forearm support above the head.

<table>
<thead>
<tr>
<th>Patient number</th>
<th>CLD (mm)</th>
<th>MHD (mm)</th>
<th>NTCP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>38</td>
<td>33</td>
<td>-5</td>
</tr>
<tr>
<td>2</td>
<td>32</td>
<td>33</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>34</td>
<td>22</td>
<td>-12</td>
</tr>
<tr>
<td>4</td>
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<td>31</td>
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</tr>
<tr>
<td>12</td>
<td>11</td>
<td>8</td>
<td>-3</td>
</tr>
<tr>
<td>Average</td>
<td>-4.7</td>
<td>-3.4</td>
<td></td>
</tr>
</tbody>
</table>

* SEM : standard error of the mean

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The normal tissue complication probability (NTCP) for excess cardiac mortality after 10-15 years was estimated from the MHD measurements using the relation between the MHD and the NTCP presented by Hurkmans et al. [5]. These NTCP values are based on the relative seriality model [6] with parameter values derived by Gagliardi et al. [3]. This model is based on full 3D dose calculations using CT data. As this data were not possible to obtain for both patient positions due to the limited bore size of the CT scanner with respect to the 'L-bar', a direct calculation of the NTCP using 3-D dose data was not possible. A paired T-test was used to test whether the differences in CLD, MHD and NTCP between the two patient positions were significant.

Results and discussion

The CLD (8 - 49 mm) and the MHD (6 - 55 mm) varied widely (Table 1). The resulting differences in these measurements between the two arm positions ranged between +1 and −12 mm for the CLD and between +1 and −10 mm for the MHD. The improvement in treatment, as seen in the decrease of the amount of irradiated lung and heart when using the forearm support is statistically significant. The mean decrease in CLD is 4.7 mm (2.6 – 6.8 mm, 95% CI) and the mean decrease in MHD is 3.4 mm (1.5 – 5.3 mm, 95% CI).

These decreases are significantly different from 0 (CLD: p-value < 0.001, MHD: p-value < 0.003).

It is difficult to quantitatively compare our results with the results presented by Canney et al., as they used evaluation parameters based on full 3D CT data [2]. However, our results are in agreement in showing a significant reduction of irradiated heart and lung by using an arm support device that positions the arms above the head instead of besides the body. Other aspects like patient stability and patient comfort should be compared between such arm supports to determine which support is optimal.

The NTCP value for excess cardiac mortality decreased on average by 3.1% (0.3 - 6.0%, 95% CI), which is significantly different from 0 (p-value < 0.02). However, the MHD values calculated for patients # 5 and #9 lie outside the range of the clinical data used to model the relation between the MHD and the NTCP and these values should, therefore, be considered with caution.
Mallik et al. [7] already reported a method to measure the amount of heart inside tangential fields in 1995. They measured the area of the heart inside the tangential fields on a simulator-CT produced CT scan through the middle of the breast. However, the contour of the heart varies considerably from patient to patient.

![Figure 1](image1.jpg)

**Figure 1.** Position of a patient using the ‘L-bar’ armrest (A) and the forearm support positioned above the head (B) during breast irradiation. The field borders of the tangential fields using the ‘L-bar’ are marked with a line on the patient. The dashed line in Figure 1B is the lateral field border when the forearm support is used.
in the cranial-caudal direction and the largest part of the heart inside the tangential fields is usually not positioned in the central part of the field. Therefore, this measurement method does not result in a very reliable prediction of the total amount of heart inside the tangential fields.

The use of the forearm support considerably reduces the amount of heart inside the treatment fields in many patients. If one, for example, uses an NTCP for excess cardiac mortality of 3% or higher as clinically unacceptable, then 10 out of 12 patients would be considered inadequately treated with the ‘L-bar’. This number is reduced to 5 patients if the forearm support is used. For these 5 patients, a different treatment technique may result in a further reduction of the NTCP. The uncertainty in the incidence of excess cardiac mortality used to fit the model parameters for the NTCP model is large [3]. However, the fit itself was rather accurate, i.e., the calculated NTCP values were well within confidence limits of the clinically observed numbers. Therefore, the NTCP values should primarily be used to rank and compare different treatment plans, with the understanding that the absolute NTCP values still have a large amount of uncertainty.

Using the forearm support, the lateral part of the breast is shifted more anteriorly (Figure 1). This is more pronounced for the heavier patients, due to the greater mobility of the breast and underlying fat. The use of the forearm support also leads to a small cranial shift of the breast. Consequently, for some patients a larger part of the axilla, latissimus dorsi and the serratus anterior muscles are included in the field. The distance of the humeral head to the cranial field edge was used to quantify the shift of the cranial field border towards the axilla by using a forearm support. On average, this shift was 7 mm (range: -9 to +26 mm) if the forearm support

**Figure 2.** Simulator image with overlay of mediolateral field outline. The central lung distance (CLD), maximum heart distance (MHD) and field length (L) are indicated.
Forearm support versus 'L-bar' support

was used. Thus, for a small group of patients, the possible reduction of lung and heart complications has to be balanced against the possible side effects arising from the irradiation of a larger part of the axilla. For patients that receive axillary region radiotherapy as part of their treatment, possible side effects are arm edema (0-2%) and shoulder malfunction (1%) [9].

In general, the comfort of the arm supports was judged similar by the patients. Sporadically, patients cannot abduct their arms sufficiently, and the forearm support is used in stead of the 'L-bar' support, which is our standard arm support. Preliminary portal imaging results show that the patient set-up accuracy does not differ between the use of the forearm support and the 'L-bar' support. It is not clear yet whether these images also can be used with sufficient accuracy to quantify the reproducibility of the MHD measurements.

In conclusion, there are several advantages using a forearm support compared to a 'L-bar' armrest: (1) the forearm support results in an overall reduction of heart and lung dose; (2) the decrease in NTCP, although small, is clinically relevant as the resulting complication, cardiac mortality, is very serious; (3) simulation time is not increased; (4) if needed, the patient can have a CT scan in the treatment position.

Acknowledgements

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References


