Improvement of breast cancer irradiation techniques
Hurkmans, C.W.

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Chapter 4

An improved technique for breast cancer irradiation including the locoregional lymph nodes

Coen W. Hurkmans
Anne E. Saarnak
Bradley R. Pieters
Jacques H. Borger
Laïn A.D. Bruinvis

The Netherlands Cancer Institute/Antoni van Leeuwenhoek Huis
Plesmanlaan 121, 1066 CX Amsterdam
The Netherlands

Abstract

*Purpose.* To find an irradiation technique for loco-regional irradiation of breast cancer patients which, compared with a standard technique, improves the dose distribution to the internal mammary (IM) - medial supraclavicular (MS) lymph nodes. The improved technique is intended to minimize the lung dose and reduce the dose to the heart.

*Methods and materials.* The standard technique consists of an anterior mixed electron / photon IM-MS field. In the improved technique, an oblique electron and an oblique asymmetric photon field are combined to irradiate the IM lymph nodes. To irradiate the MS lymph nodes, a combination of an anterior electron and an anterior asymmetric photon field is used. For both the standard and the improved technique, tangential photon fields are used to irradiate the breast. Three-dimensional (3D) treatment planning was performed for 8 patients with various breast sizes for these two techniques. Dose-volume histograms (DVHs) and normal tissue complication probabilities (NTCPs) were compared for both techniques. The field dimensions and energy of the standard technique were determined at simulation, whereas for the improved technique the fields were designed by CT-based treatment planning.

*Results.* The dose in the breast planning target volume was essentially the same for both techniques. For the improved technique, combined with 3D localization information, an improvement in the IM-MS planning target coverage is seen. The volume within the 95% isodose surface was on average 25% (range 0%-64%) and 74% (range 43%-90%) for the standard and improved technique, respectively. The heart generally receives less dose with the improved technique. However, sometimes a small but acceptable increase in lung dose is found.

*Conclusions.* The improved technique, combined with localization information of the IM-MS lymph nodes, greatly improves the dose distribution in the planning target volume for a large group of patients without significantly increasing the dose to organs at risk.
Improved IM-MS irradiation technique

Introduction

A number of studies have shown that local control increases when loco-regional radiotherapy after breast-conserving surgery is given (1-3). In contrast to previous studies an increase in overall survival is found in three recently published prospective trials in which patients were randomized between chemotherapy and radiotherapy or chemotherapy alone (4-6). To properly establish whether postoperative IM-MS chain irradiation is useful a large phase III randomized EORTC trial started in 1996 (7). It has been suggested (8) that failure to show increase in survival in previous studies is due to too high a heart dose (8,9). The reduction in breast cancer deaths is then countered by an increase of cardiac mortality. In addition, inadequate treatment techniques, resulting in possible underdosage of the internal mammary - medial supraclavicular (IM-MS) lymph nodes, could explain the adverse effects of radiotherapy found in some trials (8,9). This has led to an increased demand to optimize the treatment techniques to achieve maximum loco-regional control without increased late cardiac toxicity (10,11).

The shape of the combined breast and IM-MS target volume and its location close to the heart and lung necessitates proper matching of treatment beams and lymph node localization to avoid high doses to the organs at risk and to guarantee adequate target coverage. These matching problems were investigated by Karlsson and Zackrisson (12) and Jansson et al. (13), who developed treatment techniques which make use of the specific linear accelerator characteristics of the Racetrack microtron, of which only a few exist in the world. Others have developed more general applicable techniques, either using specifically mono-isocentric techniques (14-16), or multiple isocentre techniques (17-20). They all solved part of the matching problems, but did not address the problem of differences in the location of the lymph nodes between individual patients.

The location of the lymph nodes can be assessed with sonography and lymphoscintigraphy and spiral CT with contrast (21-25). Most lymph nodes are located within 40 mm lateral to the sternum and up to a depth of 30 mm (22). Therefore, many centers have chosen a standard IM-MS field size, accepting a small risk of a geographical miss. A drawback with using a standard anterior IM-MS field together with tangential breast fields is that a low dose region is very likely to be located either in the breast or in the IM region.

In our study, some limiting conditions regarding the implementation of an improved technique were defined beforehand. Firstly, the use of table rotations between matching fields should be avoided to minimize patient movement. Secondly, the technique should be easy to set-up at treatment, taking no more time than the standard technique. Thirdly, it should be
possible to add axillary fields without changing the technique. Finally, the technique should be suitable to implement on most types of linear accelerators.

The goal of this study was to develop an alternative technique, which improves the dose distribution in the IM-MS nodes for a large group of patients and reduces the dose to the heart when compared with the standard anterior IM-MS field technique.

Methods and materials

Patient selection and treatment planning

Data of eight patients with various breast sizes treated for left-sided breast cancer were used retrospectively in this study. The breast planning target volume (PTV) varied from 224 cc to 991 cc (average: 547 cc). The radiation fields for the standard technique were defined at simulation. Afterwards, the patients were CT scanned. The scans extended from the supraclavicular region to the most caudal part of the lungs, with a 5 mm slice separation. Radio-opaque cross markers were placed on the treatment field borders defined at simulation in order to localize the treatment fields with respect to the CT data. The patients were lying in a supine position on a flat CT table of a CT scanner with the arms lying on the table top. For this study, the treatment fields for the improved technique were defined retrospectively using the CT data. The technique can, however, be planned without using CT data if the location of the organs at risk and the target volume are determined with an other localization technique (e.g., simulation or sonography). The patients were selected on the basis of their anatomy, in such a way that various breast sizes were included in the study. Treatment planning was performed using our 3D treatment planning system U-MPlan with software version V339 (26). For photon beam dose calculations the octree/edge model (27) is used in combination with the ratio of tissue-air ratios algorithm to take inhomogeneities into account (28), whereas for the electron beams a 3D implementation of the MDAH pencil beam model (29) is applied.

1 Philips Expander AV, Philips Medical Systems, Best, The Netherlands
Definition of target volumes and organs at risk

The contours of both lungs and the heart were defined using the CT data. The breast target volume was directly outlined on each CT slice using the visible breast parenchyma, guided by the skin marks marking the field borders defined at simulation. The PTV was defined starting 5 mm beneath the skin. Non-pathological IM-MS lymph nodes are hardly or not visible at all on CT data. With the aid of other visible structures, the IM-MS clinical target volume (CTV) was defined. The MS nodes were grouped with the internal mammary IM nodes in the same target volume since there is a continuous drainage from the IM nodes to the MS nodes. The borders of the CTV of the MS lymph nodes were: ventral: sternocleidomastoid muscle, dorsal: halfway between sternocleidomastoid muscle and vertebral transverse processes, lateral: platysma and skin, medial: deep cervical muscles, cranial: thyroid cartilage, caudal: clavicle. The CTV of the IM lymph nodes was assumed to be located in an area of approximately 5 mm around the internal mammary vessels. The CTV was delineated by two experienced radiation oncologists. Although there is not a clear line between the internal mammary nodes and the mediastinal nodes, consensus about the extent of the CTV could always be reached. There was a gradual transition of the IM lymph nodes CTV into the MS lymph nodes CTV. The IM-MS PTV was defined by expanding the CTV volume with 5 mm.

Standard technique treatment plan

For retrospective analysis the fields of the standard technique were set-up on the treatment planning system using the radio-opaque markers visible in the CT-slices and the treatment parameters recorded on the patient treatment chart. Two symmetric tangential photon fields are used to irradiate the breast. The field borders are defined at simulation. The dorsal edges of the beam are made coplanar to decrease the amount of lung tissue irradiated. An anterior field is used to irradiate the IM-MS lymph nodes (Figure 1). Half of the dose of each single fraction is given with electrons in order to spare underlying structures and half of the dose is given with photons to avoid a too high a skin dose.
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**Figure 1.** Geometry of the standard technique. The field width of the IM field varies due to the curvature of the breast and sternum. The light field of the IM-MS photon field (light gray), the dorsal match plane (dark gray) and cranial match plane (hatched) are shown. The isocentre of the tangential fields ($I_T$) is located in the central plane. The IM-MS photon field (isocentre: $I_{IM,MS}$) overlaps the tangential fields on the skin by 5 mm. The direction of the IM-MS field is indicated by dashed arrows. Some contours of the IM-MS PTV are shown for clarity.

The distance from the skin to the parietal pleura just beneath the internal mammary vessels is used to choose the appropriate beam energy of the IM-MS electron field. This distance is measured in the second, third and forth intercostal space using sonography. The electron energy is chosen to have the 85% isodose covering the largest depth plus 5 mm, providing this does not result in too high doses to the organs at risk. The lateralization of the lymph nodes is not measured, and hence not used in the definition of the field borders. The medial border extends 10 mm across midline to the contralateral side, while the lateral border extends 50 mm ipsilateral. The caudal border is generally located at the fifth intercostal space to include the medial caudal part of the breast. The cranial border lies 50-70 mm above the sternal notch. A block to shield the larynx is placed in the field if needed. As can be seen in Figure 1, the field width of the IM-MS field varies due to the curvature of the breast and sternum. Therefore, an individual block is used to match the IM-MS field with the tangential fields. The shape of this individual block is determined at the simulator using the field outline of the
tangential fields as drawn on the patients skin. At the cranial side, the L-shaped field approximately extends laterally to the middle of the clavicle, thus including the medial supraclavicular nodes. For some patients there is an indication to treat a larger volume, including the lateral supraclavicular nodes and axillary nodes. For these patients, a part of the cranial section of the L-shaped field is replaced by an anterior-posterior photon field covering the supraclavicular and axillary nodes and a posterior-anterior photon field covering only the axillary nodes. In order to properly match these fields with the tangential fields, a cranial match plane is needed in which there is no divergence of the tangential fields. Geometrical solutions to this problem are given by several authors (19,30-33) using gantry, collimator and table rotations.

Figure 2. Geometry of the improved technique. The tangential fields are asymmetric (half field) with the isocentre in a cranial match plane (I_T). The long IM-MS fields of the standard technique are separated in an IM part and a MS part. The ipsilateral border is always defined at 40 mm from the sternum midline. The light field of the IM (light gray) and MS (gray) photon fields as well as the dorsal (dark gray) and cranial (hatched) match planes are shown. The isocentre of the IM and MS photon fields (I_{IM,MS}) is located at the intersection of the dorsal and cranial match planes on the skin. The IM photon field is matched to the tangential fields on the skin, whereas the IM electron field overlaps the tangential fields by 5 mm (not shown here). The directions of the IM and MS fields are indicated by dashed arrows. Some contours of the IM-MS PTV are shown for clarity.
**Improved technique treatment plan**

The patient is positioned on a breast board with the sternum horizontal. To avoid table rotation, the tangential fields are asymmetric (half field) with the isocentre in a cranial match plane which is perpendicular to the sternum midline (Figure 2). A combination of two photon fields and two electron fields is used to irradiate the IM-MS region. The long standard IM-MS field is separated in an IM part extending from the fifth intercostal space to the cranial matchplane, and a MS part cranial to the IM part. The contralateral border extends 10 to 20 mm across midline, while the ipsilateral border is always defined at 40 mm from the sternum midline.

![Figure 3](image)

Figure 3. *Transversal slice through the middle of the breast for the standard (A) technique using a 10 eV IM electron beam and improved (B) technique using a 14 MeV IM electron beam for a particular patient (patient #3). Note the low dose region present in the standard technique between the IM-MS fields and the tangential fields. The breast target volume, IM target volume and heart are shown.*
The IM and MS photon fields are both set-up with SSD = 100 cm. The fields have the same isocentre; i.e. asymmetric fields are used. The energies of the electron IM and MS fields are chosen using the available 3D CT information. If no set-up errors and mechanical inaccuracies of the linear accelerator are present, a theoretically exact match of the IM photon field and the tangential fields in the dorsal matchplane can be obtained by using gantry rotation only, without the need for individual blocking in either the tangential fields or the IM photon field (19). 16 Gy in 8 treatment fractions is given with this photon field. 34 Gy in 17 treatment fractions is given with an oblique electron field that overlaps the tangential fields by 5 mm on the skin. The electron field is turned away from the dorsal match plane by rotating the gantry 7° less than the IM photon field. This angle was found to be sufficient, and not very critical, to prevent under- and overdosages for the energy range of 6 to 20 MeV. An individual electron insert is used to shape the field. The MS electron and photon fields are anterior fields (gantry 0°). These fields are not angled towards the dorsal match plane, which facilitates the matching of these fields with axillary fields and prevents large airgap variations across the MS electron field. The separation of the parasternal fields and supraclavicular fields also enables the use of a 10 cm x 20 cm applicator available for EOS² accelerators instead of the 25 cm x 25 cm applicator. This results in less unwanted bremsstrahlung from the field defining high-Z material frame. Also to the MS region 16 Gy in 8 treatment fractions is given with the photon field, while the MS electron field with the same field size gives the complementary 34 Gy in 17 treatment fractions. Part of the dose to the MS region is given with electrons in order to spare the underlying brachial plexus and the esophagus and spinal cord.

The use of half fields to irradiate the breast limits the use of the improved technique to a field length of 20 cm. By opening the closed jaw of the tangential fields 20 mm, and shifting the cranial match plane 20 mm in the caudal direction, a field length of 22 cm is created. The divergence of the tangential field out of the cranial match plane is then only 1°. In our institute, the tangential fields are shorter than 20 cm and 22 cm in approximately 65% and 90% of all cases, respectively.

Dose prescription

The treatment plans are normalized at the ICRU reference point of the breast PTV (34). The ICRU reference dose was 2 Gy per fraction, with a total treatment dose of 50 Gy. For the standard technique, the IM-MS electron dose is specified at the depth of dose maximum. The photon dose of the IM-MS field is prescribed at a standard depth of 30 mm. For the

² Elekta Oncology Systems, Crawley, United Kingdom
improved technique, the dose of the IM and MS electron and photon fields is prescribed at the middle of the IM and MS PTV.

Data analysis

Dose-volume histograms (DVHs) were computed for the breast and IM-MS target volumes and for the lungs and heart. For the two target volumes, the volume receiving at least 95% of the reference dose was computed. For the heart, the fraction of the heart volume receiving more than 10 Gy and more than 40 Gy were computed. We have chosen 10 Gy to show that there is a distinct difference between the two techniques in this dose region.

The volume receiving a dose of 40 Gy or more represents the high dose

![Figure 4. Comparison between the standard (A) and improved (B) technique of dose-volume histograms of the breast (1), IM-MS target volume (2), heart (3) and lungs (4) for patient #2. Note the better IM-MS target coverage and lower heart dose using the improved technique.](image-url)
volume. In addition the Normal Tissue Complication Probability (NTCP) for excess cardiac mortality after 15 years has also been calculated using the relative seriality model (35) with the parameter values of Gagliardi et al. (36). The mean lung dose was used to calculate the NTCP for radiation pneumonitis (37,38).

Results

An example of the dose distributions for both techniques in the axial slice through the middle of the breast (Figure 3) shows that the dose distribution in the breast is similar in both techniques. More specifically, the size of the high dose region (110% -115%) near the dorsal matchplane is similar in both techniques. A low dose region (<70%) is present in the standard technique between the IM-MS field and the tangential fields. In this particular example, the IM-MS nodes are located in the low dose region. With the improved technique the target coverage of these nodes is improved. With the standard technique a larger part of the heart is located inside the IM fields, while in the improved technique more lung is included in these fields.

![Graph showing dose distribution comparison between standard and improved techniques.](image)

**Figure 5.** Breast volume receiving at least 95% of prescribed dose. No clinically important differences between the dose coverage of the standard and improved technique were found.
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The average field width and field length of the tangential fields for the standard technique were 9.6 cm (range: 5.9-13.0 cm) and 18.2 cm (range: 15.0-21.5 cm) and for the improved technique 9.0 (range: 6.0-13.0 cm) and 17.2 cm (range: 15.0-20.0 cm). The photon beam energy was usually 6 MV (10 treatment plans), although 4 MV (1 treatment plan) and 8 MV (5 treatment plans) photon beams were used, if this resulted in a better dose distribution. The energy of the tangential fields and IM-MS fields were kept the same for each plan. Wedge angles varied from 5°-25° and from 0°-25° for the standard and improved technique, respectively. Gantry angle varied from 39°-55° (average: 46°) and 40°-45° (average: 42°) for the standard and improved technique, respectively. The collimator angle was always 0° for the improved technique, because a breast board was used, while it was on average 12° (range: 6°-26°) for the standard technique.

The DVHs of the breast did not differ much between patients and no significant difference exists between the dose coverage of the breast using the improved technique or the standard technique (Figures 4 and 5). The breast volume receiving a dose of 95% or more was on average 95% (range: 90%-99%) and 95% (range: 85%-98%) for the standard and improved technique, respectively. For the IM-MS region and the organs at risk the histograms vary considerable between the patients due to their different anatomy and body outline. An average DVH of these volumes is not representative for the patient group and therefore only DVHs for one patient are given as an example in Figure 4. Additionally, bar graphs are presented in which the data for each patient are depicted independently (Figures 5-7). A large improvement of the IM-MS target dose coverage is seen in most patients (Figure 6). The IM-MS volume within the 95% isodose surface was on average 25% (range: 0%-64%) and 74% (range: 43%-90%) for the standard and improved technique, respectively. The electron energy of the IM-MS field in the standard technique varied between 10 and 14 MeV, while this varied between 10 and 20 MeV for the improved technique. The improvement of the dose coverage, however, does not depend on this difference alone. In patient #1, for example, part of the lymph nodes where located in the low dose region between the IM-MS field and the tangential fields (Figure 3). In patient #4, the lymph nodes were located very deep, resulting in poor dose coverage even for the improved technique using 20 MeV electrons. In general, a better dose coverage of the lymph nodes with the improved technique could be obtained if even higher electron field energies were used. This, however, would result in an unacceptable increase of dose to the organs at risk compared with the standard technique and was therefore not used.
**Improved IM-MS irradiation technique**

- **Standard technique with field sizes defined at simulation**
- **Improved technique using CT-based treatment planning**

*Figure 6.* IM-MS volume receiving at least 95% of prescribed dose. The numbers indicate the energy of the IM-MS electron field (standard technique) or separate IM and MS electron field (improved technique).

The heart generally receives less dose using the improved technique (Table 1). Only patients #4 and #8 received a larger heart dose, resulting from the choice of an IM-electron beam energy of 20 MeV and 17 MeV in stead of 14 MeV and 12 MeV, respectively. This high energy choice in the improved technique was based on the deeply located lymph nodes just anterior to the heart. Electron beam energies higher than 14 MeV were not used clinically for the standard technique, despite the fact that full coverage of the IM nodes was not achieved in patients #4 and #8. The combination of a high energy with the standard IM-MS beam direction was expected to give a too high dose to the organs at risk. The heart volume receiving a dose of 40 Gy or more was on average 3.9% (range: 0.0%-7.7%) and 2.0% (range: 0%-7.7%) for the standard and improved technique, respectively. For a dose of 10 Gy or more these figures are 60% (range: 43%-80%) and 30% (range: 23%-40%). The NTCP values of excess cardiac mortality at 10-15 years, calculated according to the relative seriality model (35) with parameter values of Gagliardi et al. (36), are 2.3% (range: 0.2%-4.1%) and 1.5% (range: 0.1%-5.8%) for the standard and improved technique, respectively.
A small increase in the mean lung dose is sometimes found using the improved technique (Figure 7). The mean lung dose was on average 5.3% (range: 3.0%-7.9%) and 6.4% (range: 4.0%-10.7%) for the standard and improved technique, respectively. The increase is due to a larger part of the lung being irradiated with the IM field. The part of the lung which receives a high dose due to the tangential fields is usually smaller for the improved technique, partly counterbalancing the increase in lung dose due to the IM field. The NTCP values for radiation pneumonitis (37,38) were on average 0.3% (range: 0.1%-0.7%) and 0.5% (range: 0.2%-1.5%) for the standard and improved technique, respectively.

Table 1. Heart volume receiving at least 10 Gy ($V_{10}$) or 40 Gy ($V_{40}$) and NTCP of excess cardiac mortality at 15 years.

<table>
<thead>
<tr>
<th>Pat #</th>
<th>$V_{10}$ (%)</th>
<th>$V_{40}$ (%)</th>
<th>NTCP (%)</th>
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<tbody>
<tr>
<td></td>
<td>Standard</td>
<td>Improved</td>
<td>Standard</td>
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<tr>
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<td>23</td>
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<tr>
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<tr>
<td>8</td>
<td>43</td>
<td>40</td>
<td>3.7</td>
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*According to Gagliardi et al., Brit. J. Radiol. 69, 839-846, 1996
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The maximum dose to the spinal cord was on average 41% (range: 33%-78%) and 33% (range: 18%-56%). To calculate the dose to the brachial plexus it is necessary to delineate this structure. However, it is almost impossible to clearly define the position of the brachial plexus on CT slices. We estimate that the dose to the brachial plexus for the improved technique will be the same or less than for the standard technique, as a larger part of the total dose in the new technique is given with electrons.

Discussion

Individualisation of treatment plan

Cuzick et al. (8) showed that excess cardiac mortality at 10 to 15 years after radiotherapy was the main factor counterbalancing a reduced number of deaths due to breast cancer obtained by adding postoperative radiotherapy to mastectomy. The comparison of the NTCP of excess cardiac mortality between different treatment plans is therefore important to optimise radiation treatment. The parameter values of the NTCP model were derived by Gagliardi et al. (36) by making new treatment plans, representing the various techniques used in the Stockholm and Oslo trials on a group of 10 model patients using CT data, assuming homogeneous radiation sensitivity within the volume of the heart and myocardium. One of their assumptions was that the treatment technique has a larger influence on irradiated heart volume than the interpatient variation. When individualized techniques are used on the basis of the localization of the IM-MS lymph nodes, this assumption seems no longer to be valid. Although in general, the improved technique results in a lower heart dose, a higher dose is found for some patients. It is important to identify this subgroup in order to decide which technique is best for them.

We have shown that there is a distinct improvement in the dose coverage of the lymph nodes using the improved technique. It should be stressed that this is due to the combination of obliquely incident IM fields in combination with more detailed information about the localization of the lymph nodes. This information was not available at the time the dimensions of the fields for the standard technique were chosen. For some patients with deeply located medial lymph nodes close to the sternum, the anterior IM fields may still be preferred. Therefore, detailed information about the depth and lateralization of the lymph nodes is needed in combination with the availability of two treatment techniques to be able to optimize the dose coverage for all patients. This information can be obtained from conventional CT data, spiralscan CT data in combination with contrast agents and
examinations as lymphoscintigraphy or sonography.

Limitations of the improved technique

The beam orientations in the improved technique with respect to the patient may also be achieved without a breast board. This would imply, however, the use of table rotations in order to produce the two match planes. In a study from Creutzberg et al. (39), no significant differences were found between the two positioning methods. Data about the set-up accuracy of the standard technique have been previously presented by van Tienhoven et al. and Holmberg et al. (40,41). The effect of these set-up uncertainties on the dose distribution in the match region of the supraclavicular fields and tangential breast fields was reported by Idzes et al. (42).

A field length of 22 cm is created by opening the closed jaw of the tangential field by 20 mm. The divergence of the tangential field at the place where an axillary field may be added is then only 1°. The resulting dose inhomogeneity, a small high dose region (105%-110%), is negligible compared with the dose inhomogeneity resulting from set-up errors (42). In general, it is important to quantify the effect of matching techniques and set-up errors on the dose distribution for each new treatment technique.

The low NTCP values found for the incidence of radiation pneumonitis for both techniques indicate that the small increase in mean lung dose in the improved technique may not be so clinically important. The mean lung dose varied between 3 and 11 Gy. In a study of Kwa et al. (37) including 540 patients, the incidence of radiation pneumonitis in this dose range was very small.

Limitations of the analysis

The position in which the patients were scanned differs slightly from the position at the simulator when the fields for the standard technique were set-up. The displacement of the skin was measured for a pilot group of patients prior to CT scanning. This was done by placing the laser lines on the skin marks with the arm in the position during simulation, moving the arm to the CT scan position, and measuring the distance from the laser lines to the marks. The movement of the marks for the IM-MS field was small; 0-2 mm in the cranio-caudal direction and on average 3-5 mm in the medio-lateral direction with a maximum of 10 mm. The treatment plan plane through the middle of the breast shifted approximately 10 mm in the cranial direction. In a detailed study of Gagliardi et al. (43), similar results were found. The CT position is also not the same as the position in which the improved technique would be carried out. The arm position could remain the same, but the patients were scanned lying supine, without using a breast board. The
breast tissue could move more caudal due to gravity, but this is probably partly prevented by the abduction of the arm. The effect of the different scan position on the calculated target coverage and dose to organs at risk was studied by extending the tangential and IM fields by 20 mm in the cranial-caudal direction. The differences between the improved technique and improved technique with extended fields were negligible.

**Other techniques**

A number of breast and IM-MS irradiation techniques have been described in the literature (12-20). If photon fields are used in combination with electron fields as in the two techniques described in this paper, the benefit of using one isocentre (14-16) is lost. However, the use of electron fields potentially results in a lower dose to the organs at risk.

The techniques described by Woudstra and van der Werf (18) and Roberson et al. (17), using electron fields, can be employed on most modern linear accelerators. They did not address, however, the problem of matching the IM and tangential fields with supraclavicular and axillary fields. This problem was addressed in the technique described by Lagendijk and Hofman (20) using two matchplanes. They used a 5° angled photon field to irradiate the IM-MS lymph nodes.

Most of the techniques discussed above were described as being applicable for all patients; i.e. only one technique would be needed, independent of the localization of the IM-MS nodes in individual patients. We have found that the optimal treatment technique does depend on the location of the IM-MS nodes, and preferably more than one technique should be available in a radiotherapy department. A technique which minimizes the dose to the heart is necessary in order to prevent excess cardiac mortality after radiotherapy for breast cancer. Most present techniques including the standard and improved technique described in this paper result in a lower heart dose than the old techniques e.g., (44). The results of EORTC study 22922 investigating the role of IM-MS irradiation will only be able to show an increased overall survival if this criterion is fulfilled.

The improved technique largely improves the dose distribution in the IM-MS nodes for a large group of patients and also reduces the dose to the heart, when compared with the standard anterior IM-MS field technique. The improvement is the result of the combined use of the improved technique and 3D localization information of the lymph nodes.
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References


