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TREATMENT TECHNIQUES FOR 3D CONFORMAL RADIATION TO BREAST AND CHEST WALL INCLUDING THE INTERNAL MAMMARY CHAIN

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Abstract—Breast, chest wall, and regional nodal irradiation have been associated with an improved outcome in high-risk breast cancer patients. Complex treatment planning is often utilized to ensure complete coverage of the target volume while minimizing the dose to surrounding normal tissues. The 2 techniques evaluated in this report are the partially wide tangent fields (PWTFs) and the 4-field photon/electron combination (the modified "Kuske Technique"). These 2 techniques were evaluated in 10 consecutive breast cancer patients. All patients had computerized tomographic (CT) scans for 3D planning supine on a breast board. The breast was defined clinically by the physician and confirmed radiographically with radiopaque bebes. The resulting dose-volume histograms (DVHs) of normal and target tissues were then compared. The deep tangent field with blocks resulted in optimal coverage of the target and the upper internal mammary chain (IMC) while sparing of critical and nontarget tissues. The wide tangent technique required less treatment planning and delivery time. We compared the 2 techniques and their resultant DVHs and feasibility in a busy clinic.

Key Words: **Internal mammary nodes, Radiotherapy, 3D treatment planning, Dose-volume histogram.**

INTRODUCTION

Breast cancer is the most common malignancy in women and accounts for one third of all female cancer.[1] Radiotherapy plays an important role in the management of breast cancer. Various beam arrangements are employed in the treatment of breast cancer. The most commonly used beam technique in the United States is 2 opposed or slightly angled tangential photon fields with a separate anterior supraclavicular photon field to cover the nodes.[2–4] A supplementary axillary field can be added when necessary.

There is a renewed interest in regional nodal treatment covering the ipsilateral supraclavicular and internal mammary nodes.[5,9] Recent randomized studies[6,7] have reported a disease-free survival benefit for post mastectomy, high-risk premenopausal women treated with radiation including the internal mammary chain (IMC).

To maximize tumor dose coverage while reducing dose to normal tissues, complex treatment planning techniques are employed. These techniques include wide or deep tangents and 4-field photon with electron fields. The aim of this paper is to compare the 2 techniques in terms of dose-volume histogram (DVH) and the feasibility in the clinic.

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METHODS AND MATERIALS

Ten consecutive patients (4 right-sided and 6 left-sided) were studied. Approval for this review was obtained from the Institutional Review Board at Magee-Women's Hospital (IRB-21-077). Patients were immobilized in a vac-bag on the Med Tech inclined breast board. The incline on the breast board was no more than 15° and was adjusted as needed to allow for the entry into the computed tomography (CT) scanner. The patient's arm was positioned so that it was extended up and behind the head, with the elbow as straight as possible. The head was turned in the opposite direction with the chin tilted up. The bag was then vacu-formed, with the patient in a reasonably comfortable treatment position. A presimulation to determine the inferior border of the supraclavicular field was performed, then the inferior border of the tangent field was marked on the patient. The medial and lateral borders were set at the time of simulation. The central axis for the medial and lateral were then determined, and radiopaque markers were placed on the medial and lateral central axis and the superior and inferior borders. The patient was then taken to the scanner along with all necessary equipment for a setup. A flat board was placed on the scanner table and the patient was set up as they were in the presimulation. The scanner couch was then driven through the aperture to make sure that the patient would clear the scanner. If the patient did not clear, the arm position was adjusted. The incline position was only adjusted if these measures failed to clear the patient in the scanner. The CT was done in a slice thickness of 0.5 cm or smaller with or without intravenous contrast. The scan was run from 3 to 4 slices above the superior boarder to 3 to 4 slices below the inferior border. The CT data was then transferred to the planning system (ADAC Pinnacle® version 4.2g) via DICOM network connection. The upper internal mammary chain, ipsilateral lung, heart, and opposite breast were outlined on the CT slices by the physician. The following beam techniques were studied: (a) partially wide tangent fields (PWTFs)[8,9] and (b) 4-field technique.[5]

PWTFs

This technique used wide tangential fields with custom blocking to treat the internal mammary nodes (IMNs). Medial and lateral coplanar tangents were used. The medial border was extended onto the opposite breast, and the lateral border was at the mid axillary line or posterior to it (Fig. 1a). The borders were set with the use of 3-dimensional (3D) rendering of the lateral and the medial borders are determined to ensure coverage of the IMC region, through the use of beams-eye view (BEV) (Fig. 1b) adequate blocking could be added to spare to spare the opposing breast, heart, and lung. The block could be adjusted to follow the chest wall at the rib cage so that the IMC, breast and chest wall were treated while sparing normal lungs. Treatment planning ranges from 45 to 60 minutes.

Four-field technique

This technique employs 4 separate fields to treat the chest wall and IMC. A direct photon and an angled electron field covered the IMC region and 2 shallow tangents covered the chest wall, but exclude the IMC (Fig. 2). The medial tangential border was moved laterally so that it did not include the IMC. The lateral border was at the mid-axillary line or posterior to it, depending on anatomical considerations necessary to cover the entire ipsilateral chest wall. For the mixed beam setup, the photon field was set up so that the central axis abutted to the supraclavicular field. The IMC was treated with a direct en face half beam blocked photon field and an angled electron field. The photon field was set up so that the central axis abutted to the supraclavicular field. The lateral border may overlap the medial tangent by 0.5 to 1 cm. Utilizing the BEV and 3D rendering tools, a block could be shaped to follow the curve of the medial tangent line, ensuring just the right amount of beam overlap. The electron field was designed at 110 to 120-cm SSD and is angled 3 to 5° less than the medial tangent. The lateral edge of the field abuts the border of the medial tangent. The total width of the field should cover the same area around the IMC as the photon field. Generally, the electron field, on the skin, will extend approximately 2 cm wider medially than the photon field. The energy used for the electron field is dependent upon the depth of the IMC nodes as determined by CT and the required treatment dose coverage. The dose-weighting ratio is generally 80:20 between electrons and photons but can be adjusted as needed (Fig. 2). This technique usually required 4 to 5 hours of planning time.

RESULTS AND DISCUSSION

Dose distributions and hot spot areas were evaluated and DVHs were generated from the Pinnacle 3D dose planning system. No heterogeneity corrections were applied. DVHs for IMC, heart, and lung were obtained and compared. Both PWTFs and 4-field technique produced adequate dose coverage of breast tissue or chest wall.

IMC coverage

When comparing the DVH for the IMC, 4 points need to be taken into consideration (Fig. 3).

1. Relative maximum dose. In this case, the relative maximum doses for both are the same, 54.0 Gy.
2. Minimum dose. The minimum dose for both techniques is not the same, but is fairly close. The PWTFs technique is at 47.4 Gy, while the 4-field technique is at 45.4 Gy.
3. The difference between minimum and maximum doses. This gives a measure of the homogeneity of the target volume. Our review revealed that the difference was smallest with the PWTFs technique. The spread between the minimum and maximum dose for the PWTFs technique is smaller than the spread for the 4-field technique. Therefore, the PWTFs technique is more homogenous.
4. The regional slope of the curves. The slope of the curves of both techniques from 0% volume to 80% volume is identical. As the curves pass the 80% mark, they start to separate, the PWTFs technique curve stays sharp while the 4-field curve start to dull.

Lung

As a rule for our 3D IMC cases, we have set a standard of no more than a 30% volume of lung, including those volumes covered by any supraclavicular field treated, will receive more than 20 Gy maximum. There are 4 dose points to consider in evaluation the lung DVH (Fig. 4). (1) 2.5 Gy: Lung volume for the PWTFs technique is 38%, while the volume for the 4-field is 85%; (2) 5 Gy: Volume for the PWTFs technique is 31%, while 4-field is 70%; (3)10 Gy: Volume for PWTFs technique is 30%, while the 4-field is at 43%; and (4) Crossover point: The point at which the curves cross each other is at 17.5 Gy, very close to the maximum dose. The volume at this point is 28%.

The PWTFs technique treats a smaller volume (28–38%) of lung to a higher dose. The 4-field technique treats a greater volume (70–85%) at a low dose before