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Depth Doses in the Region of Overlap of the Supraclavicular and Internal Mammary Portals in Postoperative Radiation Therapy of Carcinoma of the Breast

Joel E. White, MD;* Michael Reidy, BS;** and Murray Boles, MD*

Computer-generated depth-dose data was obtained for the region of overlap of the internal mammary and supraclavicular portals utilized in post-operative radiation therapy for carcinoma of the breast. A phantom arrangement was created and measurements were obtained and compared with computer-generated depth doses for this arrangement. The actual measured and computer-generated values agreed to within 3%. On the patients measured at the center of the overlap region, the dose was found to vary from 3323 rets to 2571 rets over a depth range of 2-6 cm. It is occasionally the practice to ignore small areas of overlap. The dose at the center of this region is significant even for small areas, and therefore, the corner should be blocked from one of the two fields.

In the early years of radiation therapy, it was common practice to allow small areas of overlap of adjacent fields. As clinical knowledge expanded, experience demonstrated that there was an increased risk of complication and this practice was largely abandoned.

Benson angiographically demonstrated arterial stenosis at the area of intersection of two radiation therapy portals. One of these was the subclavian artery a few centimeters lateral to the sternoclavicular junction. To emphasize that the practice of allowing overlap corners should be completely abandoned, we undertook an investigation of the dosage in this region.

Material and Method

It is common practice to deliver post-mastectomy radiation therapy to the lymphatic drainage areas of the removed breast. Patients with specific indications also receive radiation therapy to the chest wall. The current study includes six consecutive patients undergoing radiation therapy to the lymphatic drainage areas of the breast. Patients receiving additional therapy to the chest wall were excluded.

All patients were treated utilizing 60Co teletherapy with an 80 cm source-axis distance. The average size of the supraclavicu-
Schematic of the treatment fields utilized in postoperative radiation therapy of carcinoma of the breast. The dose for the suprascapular field is calculated at 5 cm below the skin surface at the central axis, and the internal mammary at 3 cm depth. Point "A" is at the center of the region of overlap of the two fields.

Results

1—Phantom simulation. The measuring system consisted of a Victoreen 555 Radacon II electrometer with a 100 HA chamber, an 80-cm SAD AECL 60Co unit, and a phantom of lucite blocks. Field size for each field was specified at 80 cm from the source. Central axis dose was measured at 3 or 5 cm depth by placing the center of the chamber at 80 cm SAD and then placing 3 or 5 cm of lucite between the chamber and source. Off-axis depth doses were measured by defining a 1 x 5 cm section in the corner of each field, placing the chamber center of this area (Point A, Figure 1) with 2 to 6 cm of overlying lucite and with the SAD at 3 or 5 cm. Ratios of the off-axis dose to the central axis dose (Do/Dc) were then computed.

The contour coordinates for the phantom along with the treatment plan were fed into a GE 440 time-sharing computer. Cunningham's program for calculating off-axis doses was employed. The computer-generated depth doses for the phantom were then compared to those obtained experimentally. Figure 2 shows that for the internal mammary field, the computer-generated ratio of off-axis (Do) to central axis (Dc) dose agreed with that actually measured in the phantom to within ±1% for various depths ranging from 2 to 6 cm below the skin surface. Figure 3 compares similar data for the simulated suprascapular field. This data agrees to within ±4%.

II—Computer-Generated Depth Doses on Patients. The area of overlap for each patient was determined (Table I). The data and contour coordinates for each patient were tabulated and fed into the computer. Depth doses were calculated at 1 cm intervals below the center (Point A, Figure 1) of the overlap region, starting at 2 cm depth and down to 6 cm depth. The contribution of the internal mammary field (Figure 2) was calculated to range from 70-95% of the central axis depth dose. Figure 4 details the
range of dosages at various depths below Point A, Figure 1, for 200 rads delivered to 3 cm depth at the center of the internal mammary field. The absolute values depend in part upon the slope of the chest, but in our patients were calculated to range between 177-190 rads at 2 cm depth to 140-150 rads at 6 cm depth. The supraclavicular field was calculated to contribute 82-95% of its central axis dose to the off-axis point of interest (Figure 5). For 200 rads to 5 cm depth at the center of the field, the dose 2 cm below the point of interest ranged from 220 to 240 rads and at 6 cm depth from 175 to 185 rads.

The contribution of both fields to the off-axis point of interest is summated and illustrated graphically in Figure 6. At 2 cm below the skin surface, the total dose per fraction would be from 400 to 430 rads and at 6 cm depth, 315 to 333 rads.

**Discussion**

The subclavian artery originates at about the level of the sternoclavicular junction, then runs supero-laterally along the inferior margin of the clavicle, ultimately becoming the axillary artery. Its depth below the skin surface is highly variable and depends upon the amount of subcutaneous tissue present in this region. However, in patients who have had radical mastectomies, most of the subcutaneous tissue in this area will have been removed. The center of the area of overlap (Point A, Figure 1) in most patients lies about 1 cm lateral to the sternoclavicular junction.
Similar data as Figure 2, supraclavicular field. Axis depth of 5 cm used for the comparison.

Figure 4
Computer calculated depth doses for the internal mammary field.

Figure 5
Computer calculated depth doses for the supraclavicular field.

Do/Dc
Dc = CENTRAL AXIS DOSE AT 5 CM DEPTH
Do = OFF AXIS DOSE AT PT. "A" AT DEPTH
○ COMPUTER CALCULATION
■ MEASURED IN PHANTOM

Similar data as Figure 2, supraclavicular field. Axis depth of 5 cm used for the comparison.
Westling, Svensson, and Hele\(^3\) reported complications following post-operative radiation therapy consisting of subcutaneous fibrosis in the supraclavicular field, mild lung reactions, and occasional lesions of the cervical plexus. Their dosage and fractionation scheme, however, was quite different. They estimated that the maximum dose in the region of overlap would be somewhere around 130\%. They used 400 rads per fraction per field, giving 11 fractions over 23 days. The NSD, according to the Ellis formula,\(^4\) is 2278 rets.

With the exception of Benson,\(^1\) there are no reports in the recent literature relating radiation therapy to vascular stenosis. Doses per fraction calculated in the overlap region (Figure 6) vary from 415 rads at 2 cm depth to an average of 325 rads at 6 cm depth. Even for the patient whose overlap region is only 1 x 2 cm, the total dose per fraction at 4 cm depth was 357.2 rads.

The average NSD’s are listed with their corresponding average total doses in Table II. This shows a range of 2571 to 3323 rets for the various depths.

### Summary and Conclusions

The total doses for various depths below the center of the area of overlap of the supraclavicular and internal mammary ports were calculated on a GE 440 time-sharing computer and found to range from 2571 to 3323 rets. Although the clinical significance was not investigated in this study, it is well established that such doses will result in long-term connective tissue.

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**Table I**

<table>
<thead>
<tr>
<th>Patient Number</th>
<th>Area of Overlap</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 x 5</td>
</tr>
<tr>
<td>2</td>
<td>1 x 6</td>
</tr>
<tr>
<td>3</td>
<td>1 x 2</td>
</tr>
<tr>
<td>4</td>
<td>1 x 5</td>
</tr>
<tr>
<td>5</td>
<td>1 x 5</td>
</tr>
<tr>
<td>6</td>
<td>2 x 4</td>
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</tbody>
</table>

Area of overlap of the supraclavicular and internal mammary portals in 6 patients.

**Table II**

<table>
<thead>
<tr>
<th>Depth</th>
<th>Total Dose (RADS)</th>
<th>NSD (RETS)</th>
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</thead>
<tbody>
<tr>
<td>2 cm</td>
<td>10,500</td>
<td>3323</td>
</tr>
<tr>
<td>3 cm</td>
<td>9,800</td>
<td>3102</td>
</tr>
<tr>
<td>4 cm</td>
<td>9,250</td>
<td>2928</td>
</tr>
<tr>
<td>5 cm</td>
<td>8,675</td>
<td>2746</td>
</tr>
<tr>
<td>6 cm</td>
<td>8,125</td>
<td>2571</td>
</tr>
</tbody>
</table>

Nominal standard doses for various depths in the center of the overlap region, calculated according to the Ellis formula.
changes. Computerized dosimetry was chosen as a method of emphasizing the importance of eliminating even small areas of overlap. Our current practice is to block the field which delivers the smallest contribution to the area of overlap.

References


