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COMPARISON OF VARIOUS RADIATION TECHNIQUES IN TREATMENT OF THE BREAST AND CHEST WALL

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Clear evidence indicates that radiation therapy should continue to play a major role in the curative management of patients with mammary carcinoma (MANSFIELD 1976, PROSNITZ et coll. 1977, WEBER & HELLMAN 1975). When it is used in the primary or adjuvant treatment, the aim has been to include within the target volume the tumor if present, areas of possible recurrence and adjacent areas of potential spread of disease. Many irradiation techniques are in use at various institutions to accomplish these goals. Apart from estimates and approximate calculations, there is little published experimental data concerning dose distributions in the region of the treatment volume for these techniques. A dosimetric analysis of some techniques in current use for treatment of the breast and chest wall is now reported.

Method

Several irradiation techniques using the three treatment machines available in this institution, a Theratron-80 Cobalt unit, a Clinac 4 MV linear accelerator and an Asklepitron-45 betatron were examined. Specific details of the techniques used by some institutions were requested and have been reproduced as closely as possible in these experiments. The dose measurements were initially made in an Alderson-Rando phantom. In order to obtain distributions in multiple parallel planes, a chest phantom with one breast intact and simulating the dimensions of an average patient was fabricated using presswood (masonite) sheets.

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Kodak RP/V film and LiF-Teflon disk dosimeters were used in the dosimetric measurements (MANSFIELD et coll. 1976). While still in its package, the film was cut in the dark room to fit the cross-sectional contour of the phantoms, placed firmly between two slabs and sealed with light-tight tape. The TL dosimeters were placed on the surface of the phantom. Both the film and the TL dosimeters were left in place during the entire treatment. Film density was determined on an SHM automatic iso-density plotter and converted to isodose values using calibration curves of density vs. dose. The TL dosimeters were read on Harshaw Model 2000 TL reader, using standard procedures.

Results and Discussion

Treatment of chest wall. In routine irradiation after radical mastectomy, the treatment volume will include the ipsilateral supra-calvicular and internal mammary lymph nodes and occasionally the chest wall, usually employing a-shaped or multiple-field arrangement for the nodes and opposed tangential fields for the chest wall. The irradiation techniques used at institutions A, B, C and D are designed to treat the internal mammary nodes and chest wall.

Institution A uses 15 MeV electrons to irradiate the anterior mediastinal field. The chest wall is irradiated by two adjacent lateral 7 MeV electron fields. Lucite wedges are used for the overlap regions. Fig. 1 shows the irradiated area and dose distribution in the central plane. Treatment volume includes the chest wall and both internal mammary nodes. Dose within the target volume is uniform to ± 10 per cent from skin to the desired depth and there is a sharp fall of dose beyond the depth of interest. The dose at depth and its relative dose distribution can be influenced by varying the electron energy of the treatment fields. When patched fields are used to cover large areas, high dose regions of about 1 to 2 cm in diameter can occur in the overlap regions. These high dose regions can be reduced with better design and positioning of the lucite wedges at the overlapping edges of the fields.

The chest wall and internal mammary nodes are treated by opposed isocentric tangential fields using 4 MV photons at Institution B. The medial border is 3 cm past the midline with 5° angulation of the tangential beams producing an angle of 190° between the two fields. Dose distributions for this approach appear in Fig. 2. This technique provides a dose uniformity to within 15 per cent in the chest wall. However, no bolus is used, thus the skin doses range from 40 to 60 per cent of the maximum chest wall dose. Since the intent of this technique is to include the ipsilateral internal mammary nodes in the treatment volume, it appears that it is difficult or impossible to accomplish this without irradiating a large portion of the lung.

Institution C uses 25 MV photons to irradiate chest wall and internal mammary nodes. The medial beam is angled 65° and the lateral beam 120° so that the divergent beams oppose through the entry points. A 3 cm bolus starts 4 cm contralateral to the midline. This technique was simulated by using 45 MV photons. The dose distributions in the target volume are similar to institution B but with improved uniformity

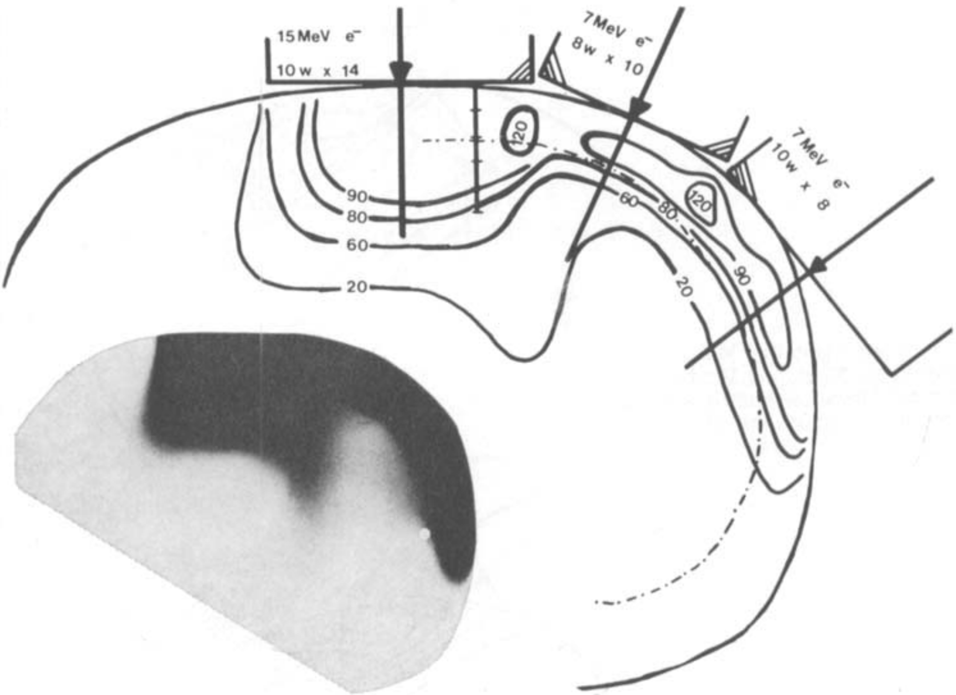

Fig. 1. Irradiated area and isodose distribution in the central plane for technique used by Institution A: Patched electron fields 15 MeV beam for the anterior field and two oblique 7 MeV beams for the chest wall. Lucite wedges positioned at the overlapping edges of the fields.

of the dose (Fig. 3). The dose from the skin surface to the desired depth is within 10 per cent of maximum. In this technique an attempt is made to treat the contralateral internal mammary nodes, resulting in a large portion of the lung being included in the irradiated volume.

Institution D uses opposed tangential 10 MV photon fields. The medial border extends 2 cm past midline on the contralateral side. The lateral bordeı extends to the mid-axillary line. Point of dose delivery is 3 cm deep to the midline. The medial tangent is angled 5°. Four MV photons were used to simulate the technique. It is evident that the chest wall is treated to a dose uniformity of 20 per cent (Fig. 4). Because no bolus is used, the skin doses are 25 to 45 per cent of the maximum dose and would be even lower for the 10 MV photon beams. This implies that the skin and subcutaneous tissues will be underdosed by this technique. Also, the internal mammary nodes at 3 cm depth receive less than 80 per cent of the dose. The amount of irradiated volume would be even larger for adequate treatment of these nodes.

Treatment of the intact breast. When the intact breast is irradiated, the goal is to achieve a uniform dose distribution within the tumor volume and the adjacent areas

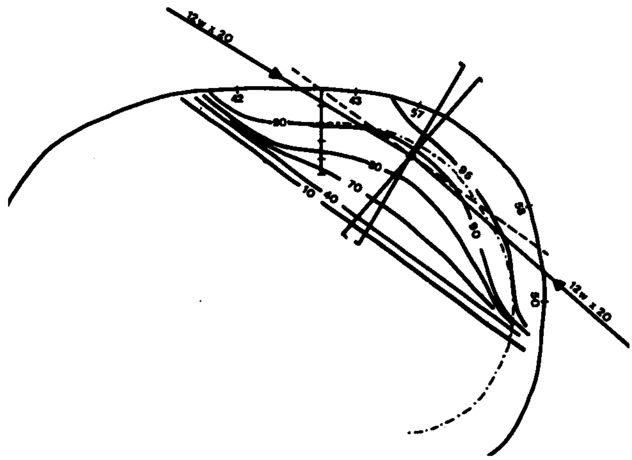

Fig. 2. Institution B: 4 MV photons with 5° angling for both tangent fields, isocentric set-up, medial border 3 cm past midline.

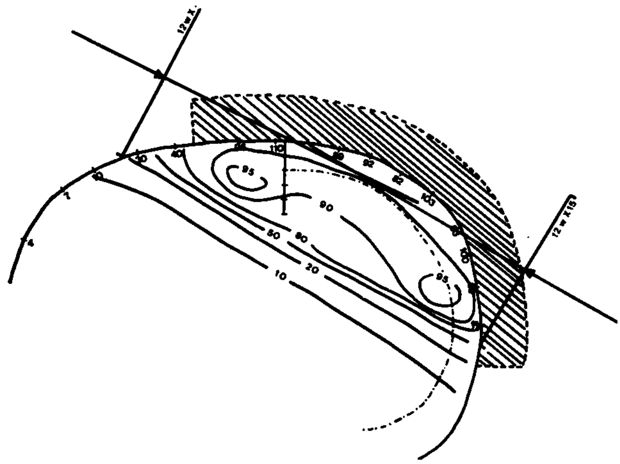

Fig. 3. Institution C: 45 MV photons with 3° angling for both tangents to match beam divergence, medial border up to halfway across opposite breast, 3 cm thick bolus up to 3 cm past midline.

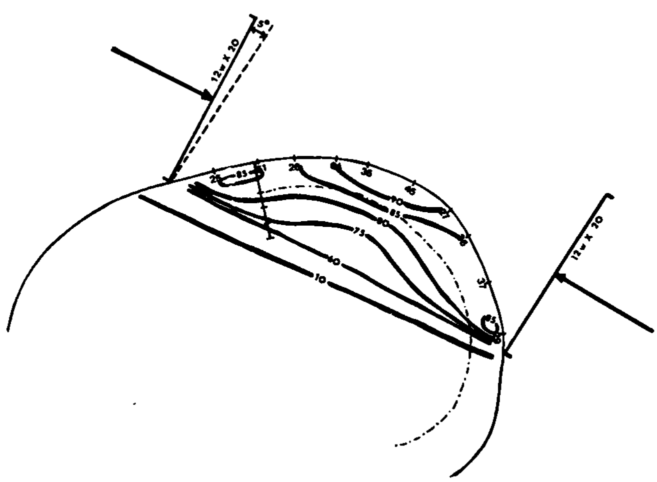

Fig. 4. Institution D: 4 MV photon tangential fields with medial tangent angled 5°, medial border 2 cm past midline.

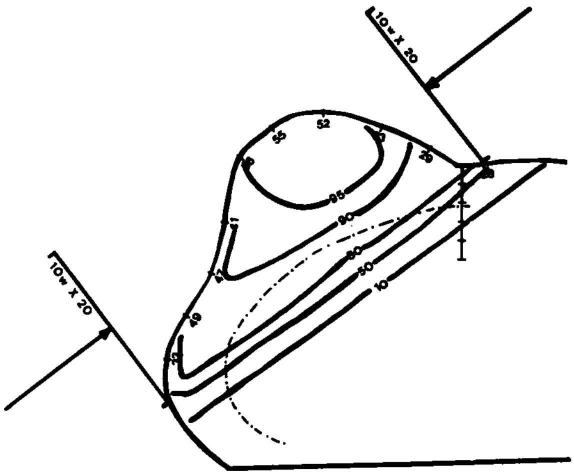

Fig. 5. Institution E: 4 MV photon 180° opposing tangential beams, 15° collimator rotation to extend treatment volume to superior nodes.

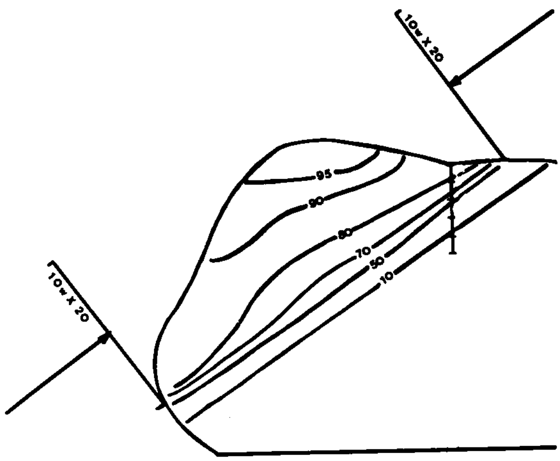

Fig. 6. Irradiated volume and isodose distribution in the plane 5 cm superior to the central plane for institution E technique.

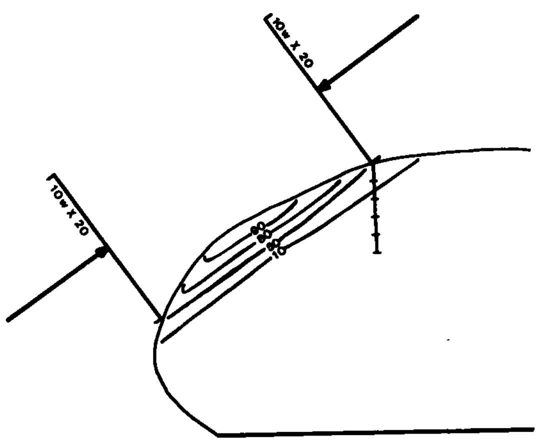

Fig. 7. Irradiated volume and isodose distribution in the plane 9 cm inferior to the central plane for institution E technique.

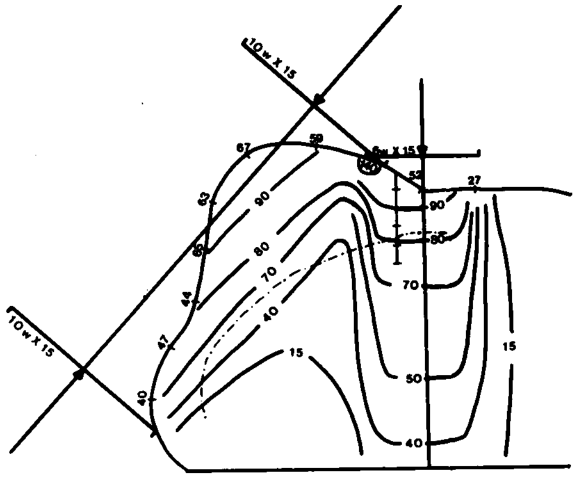

Fig. 8. Institution F: ^{60}Co photon beams, 180° opposing tangents, anterior field and medial tangent overlap 1 cm, no bolus.

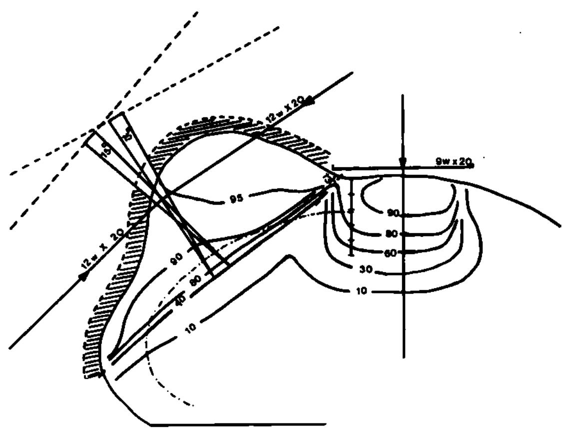

Fig. 9. Institution G: 4 MV photon tangential fields with 5° angling for both tangents, 15° wedges, isocentric set-up, 1 cm thick bolus; 15 MeV electron beam for anterior field, 0.5 cm overlap with medial tangent.

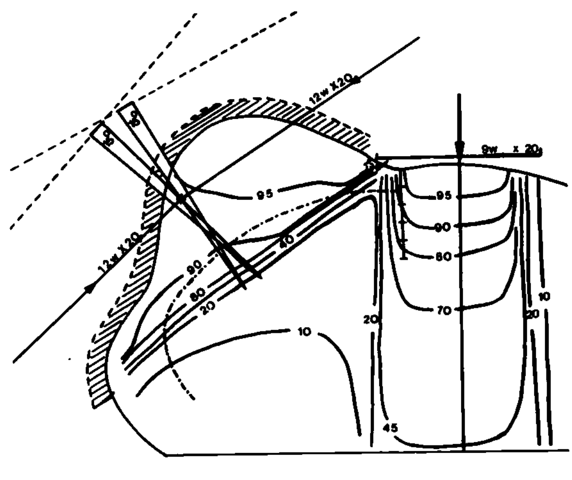

Fig. 10. Same technique as in Fig. 9 with a 4 MV photon beam for the anterior field.

of potential spread of disease. Irradiation techniques used at institutions E, F and G are designed to accomplish this.

Institution E uses tangential 4 MV photons to irradiate the chest wall and breast. Using a 15° collimator rotation the mammary nodes and axilla are also included in the treatment volume. Due to the collimator rotation, the medial beam passes 2 cm contralateral to the midline for a section 5 cm superior to the central plane and 4 cm ipsilateral to midline for a section 9 cm inferior to the central plane. The dose distributions in multiple planes parallel to the central plane appear in Figs 5 to 7. This technique gives a variable tangential treatment volume throughout the length of the field. In the upper portion of the thorax, more lung and normal soft tissue are within the treatment volume. In the lower thorax and abdomen less lung and liver tissue is included in the volume. The dose in the target volume is uniform within 20 per cent. Because of lack of bolus, the skin doses are 30 to 55 per cent of maximum dose. This technique treats only the upper ipsilateral internal mammary nodes.

^{60}Co photon beams are used at institution F to irradiate the internal mammary nodes by an anterior field and the breast or chest wall by opposed tangential fields with occasional partial wedging. The overlap from the medial tangent and anterior mediastinal field is 1 cm. This is the most commonly used treatment technique. This technique was reproduced without wedges for the tangential fields and the dose distributions appear in Fig. 8. The total irradiated volume is larger than in all the previously described techniques because of a separate anterior field used to irradiate the internal mammary nodes. Through this anterior field as much as 40 per cent of the maximum dose is delivered to the cord. The uniformity of dose within the tangential treatment volume is within 20 per cent, the skin dose being 40 to 50 per cent of maximum but can be improved by the addition of bolus. In the overlapped region, a small volume of tissue can receive doses as high as 150 per cent of the maximum dose.

Institution G uses either a 15 MeV electron (Fig. 9) or 4 MV photons (Fig. 10) to irradiate the internal mammary nodes by an anterior mediastinal field. Four MV phonton beams are used to treat the chest wall. These fields are isocentric and tangential. The tangential fields are opposed, wedged and angled 5° to give an angle of 190°. There is a 0.5 cm overlap of the medial tangent and anterior mediastinal fields. The institutions G and F have similar techniques. The anterior field can be used to irradiate one or both internal mammary node chains. When electrons are used for the anterior field certainly the total irradiated volume is decreased. Also, by appropriately angling the tangential fields the dose to the lung can be further decreased. The dose uniformity in the treatment volume is within 10 per cent.

Conclusion

A comparison of the measured dose distributions for a number of the most commonly used techniques for the irradiation of the chest wall and adjacent nodes has been presented. This investigation has shown that although the dose distribution within the treatment volume is similar there are local differences in treatment volume and the dose to skin and superficial tissues. A definite trend appears in modern treatment techniques to arrive at dose distributions that adequately encompass the target volume while at the same time the dose to normal structures is minimized.

Acknowledgements

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SUMMARY

Radiation therapy will continue to play a major role in the curative management of patients with mammary carcinoma. For this reason, a comparison was made of the dose distributions and techniques used by several leading institutions in the treatment of the chest wall and internal mammary nodes. The dose distributions within the treatment volumes were similar. However, some unique differences within the treatment volume, as well as in the skin and superficial tissues were found.

ZUSAMMENFASSUNG

Die Strahlentherapie wird weiterhin eine grosse Rolle bei der kurativen Behandlung von Patienten mit Brustkarzinom bilden. Aus diesem Grunde wurde ein Vergleich über die Dosisverteilung und die Techniken, die von verschiedenen leitenden Institutionen bei der Behandlung der Thoraxwand und der Lymphknoten der Mammaria interna verwendet werden, vorgenommen. Die Dosisverteilung innerhalb der behandelten Volumina war ähnlich. Vereinzelte Unterschiede wurden jedoch innerhalb des behandelten Volumens, sowohl für die Haut als auch für das Oberflächengewebe, gefunden.

RÉSUMÉ

Le traitement par les radiations continuera à jouer un rôle de premier plan dans le traitement curatif des malades atteintes de cancer du sein. C'est pourquoi les auteurs ont comparé les distributions de doses et les techniques utilisées dans plusieurs grands centres pour le traitement de la paroi thoracique et des ganglions mammaires internes. Les distributions de doses dans les volumes traités sont semblables. Les auteurs ont cependant trouvé quelques rares différences dans le volume traité ainsi qu'au niveau de la peau et des tissus superficiels.

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