ACTA RADIOLOGICA

PUBLISHED BY THE SOCIETIES OF MEDICAL RADIOLOGY IN DENMARK, FINLAND, NORWAY AND SWEDEN

Vol. 18
Fasc. 4

ONCOLOGY RADIATION PHYSICS BIOLOGY

1979

POSTOPERATIVE RADIATION THERAPY IN MAMMARY CARCINOMA STAGE II

Target volume, organs at risk, absorbed dose, time-dose schedule, and dose to organs at risk in a prospective investigation

Å. ARWIDI, K. ASPEGREN, N.-E. AUGUSTSSON, LO. HAFSTRÖM, A. NORGREN and G. SVAHN-TAPPER

In clinical research on malignant diseases, randomized prospective investigations are being widely used. The advantages are obvious, e.g. rapid accumulation of sufficient data to allow a statistical analysis of the results. Strict control of surgical and irradiation measures are necessary in order to obtain valid data.

On January 1, 1978, a prospective investigation was started in the Southern Region of Sweden in order to evaluate different combinations of treatment of carcinoma of the breast stage II, in particular surgery with adjuvant chemotherapy or hormonal treatment, or in combination with postoperative irradiation. The region has a total of 1.5 million inhabitants, and all 15 Departments of Surgery and the two Departments of Oncology participate. It has been estimated that in order to detect any difference in treatment results between the three groups, amounting to 10 per cent ($p < 0.05$), it was necessary to include at least 150 patients in each treatment group. The patients would then have to be included for at least 3 years.

The surgical procedure is standardized and consists of a modified radical mastectomy, saving the pectoral muscles, with dissection of the axilla to the level of the axillary vein, including a biopsy of the intrapectoral nodes.

The irradiation is delivered at the Departments of Oncology in the region.

From the Departments of Oncology, Radiation Physics, and Surgery, the University Hospitals, S-221 85 Lund and S-214 01 Malmö, Sweden. Submitted for publication 14 November1978.

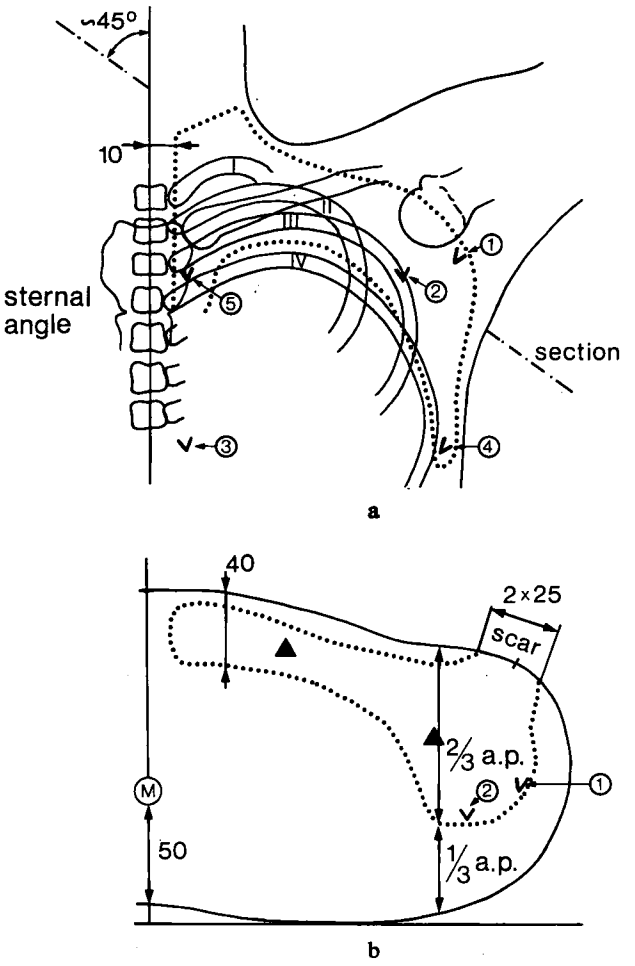


Fig. 1. Target volume in axilla and in infra- and supraclavicular fossae. a) Antero-posterior projection. b) Oblique section from level of vocal cords through supra- and infraclavicular fossae and axilla, at 45° from the median plane. Distances in mm. ... = border of the target volume/area. ▲ = dose specification point. V = metallic clips (cf. Fig. 2). M = spinal cord.

Since in radiation therapy 'physical treatment planning is dependent on the delineation of the target volume(s) and the prescription of the target absorbed dose' (ICRU Report 29, 1978), a common programme was adopted for the postoperative irradiation. A description was made of the target volume and other anatomic details in a patient of normal size and shape. For some patients, the description may not be applicable, and then an individualized evaluation is made in order to achieve the prescribed target absorbed dose. The absorbed dose distribution and the time-dose relation, etc. was also defined. The irradiation programme in use is described in this report.

Target volume

The definition of target volume was that of ICRU Report 29: 'The target volume contains those tissues that are to be irradiated to a specified absorbed dose according

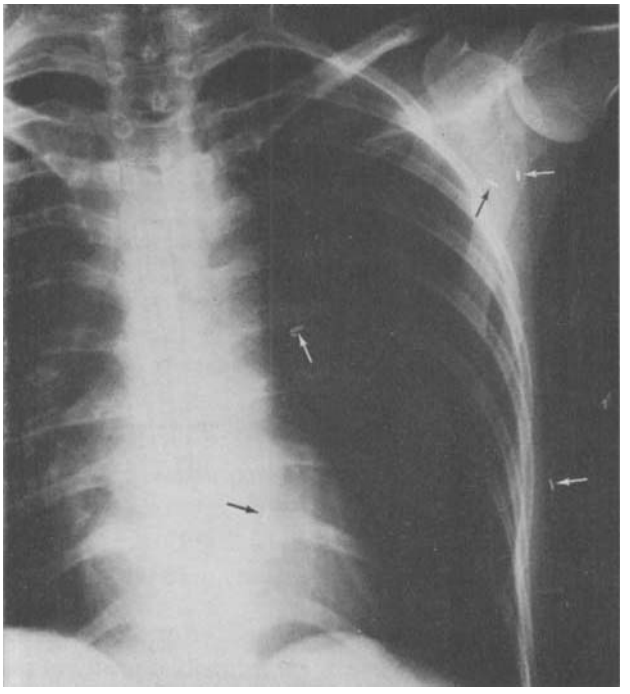


Fig. 2. Position of metallic clips. Beam centred as in Fig. 5 a.

to a specified time-dose pattern. For curative treatment the target volume consists of the demonstrated tumour(s), if present, and any other tissue with presumed tumour ...'.

For the patient with carcinoma of the breast, adequate information on lymph node topography is available in the literature (STIBBE 1918, KETT et coll. 1970, HULTBORN et coll. 1971, RAGNHULT et coll. 1972, WEISENBURGER & JUILLARD 1977). In the present investigation the target volume was considered continuous, but due to anatomic variations and variations in the extent in the target volume and also for technical reasons, the target volume was described as consisting of three parts: (1) lymph nodes and operation cavity in the axilla and the infra- and supraclavicular fossae, (2) the internal mammary nodes, and (3) the chest wall. With the patient in the supine position and arms raised, the borders of the target volume were defined as follows:

Target volume in the axilla and infra- and supraclavicular fossae. The medial border of the target volume in an antero-posterior projection (Fig. 1 a) is 10 mm from the midline, and the cranial border extends from the region of the vocal cords 45° laterally-cranially. Then it follows the margin of the trapezius muscle down into the axilla where the target volume covers the medial two-thirds of the humeral head. From this point it extends downwards lateral to the thoracic wall including also the lateral parts of the operation field, as indicated by metallic clips placed during surgery

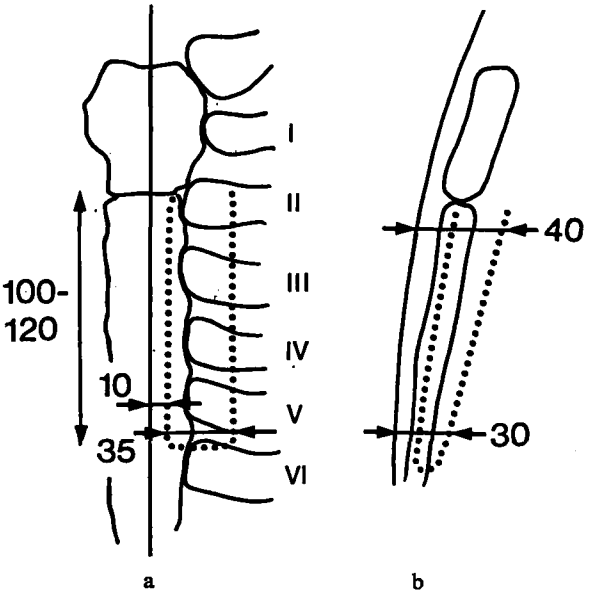


Fig. 3. Target volume for internal mammary nodes. a) Antero-posterior projection. b) Sagittal section. Distances in mm.

at 5 points. This is done in order to diminish the risk of geometric error. These points are as follows (Figs 1, 2): (1) most laterally in the axilla, (2) medially-dorsally in the axilla, (3) in the caudal-medial corner, (4) in the caudal-lateral-dorsal corner, and (5) at the cranial-medial border. The caudal border of the target volume starts at the sternal angle 10 mm from the midline and then extends laterally 35 mm. It then runs 30 mm caudal to the lower border of the clavicle to turn laterally-caudally along a line that is represented by the vertical projection (patient supine) of the space between the 3rd and 4th ribs posteriorly. Laterally it then joins the caudal border of the axillary target, as described; this position is indicated by a metallic clip.

In the oblique section (Fig. 1 b) approximately at a 45° angle with the midline, from the vocal cord region through the supra- and infraclavicular fossae and the axilla, the target volume appears as a target area. Its depth in the supra- and infraclavicular fossae is from 3 to 40 mm from the surface of the skin. At a distance of 70 mm from the midline (= 100 mm in the oblique section) the dorsal border of the target area starts to merge with the dorso-medial border of the axillary target area. Here it follows the thoracic wall backwards to the most dorsal part of the axilla at a distance from the ventral surface of two-thirds of the antero-posterior distance. This point is indicated by a metallic clip. Then the border of the target area turns ventrally-laterally towards the skin. The skin surface near the surgical scar is included to a distance of 25 mm from the scar.

Target volume for the internal mammary nodes. In the antero-posterior projection (Fig. 3 a) the medial border of the target volume is 10 mm and the lateral is 45 mm from the midline. The cranial border is at the level of the sternal angle where it

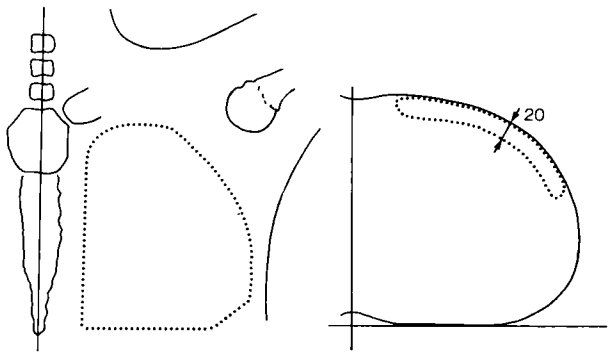


Fig. 4. Target volume for the chest wall. a) Antero-posterior projection. b) Transverse section. Distance in mm.

reaches the medial part of the infraclavicular target volume. The caudal border includes the space between the 5th and the 6th ribs at the sterno-costal junctions. The depth extends (Fig. 3 b) from the centre of the sternal body down to 40 mm from the surface of the skin cranially and 30 mm caudally, respectively.

Target volume for the chest wall. In the antero-posterior projection (Fig. 4 a) the chest wall target volume joins the previously described target areas medially, cranially and laterally. Caudally it includes the whole operation field at least to the level of the inframammary fold. The depth (Fig. 4 b) extends from the surface of the skin down 30 mm cranially and 20 mm caudally.

Scars and drainage exits are included in the target volume to a distance of 25 mm. When the skin wound extends more medially than 35 mm from the midline, the medial border of the chest wall target extends beyond the target for the internal mammary nodes.

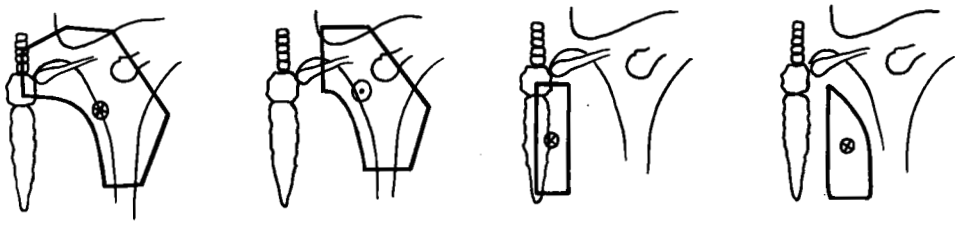
Organs at risk

Organs at risk are organs in or near the target volume particularly sensitive to radiation and influencing the treatment planning and the prescribed dose (ICRU Report 29).

The present organs at risk are: (1) the spinal cord, which is considered to lie at a distance of 50 mm from the dorsal skin surface, (2) the lung, and (3) the skin.

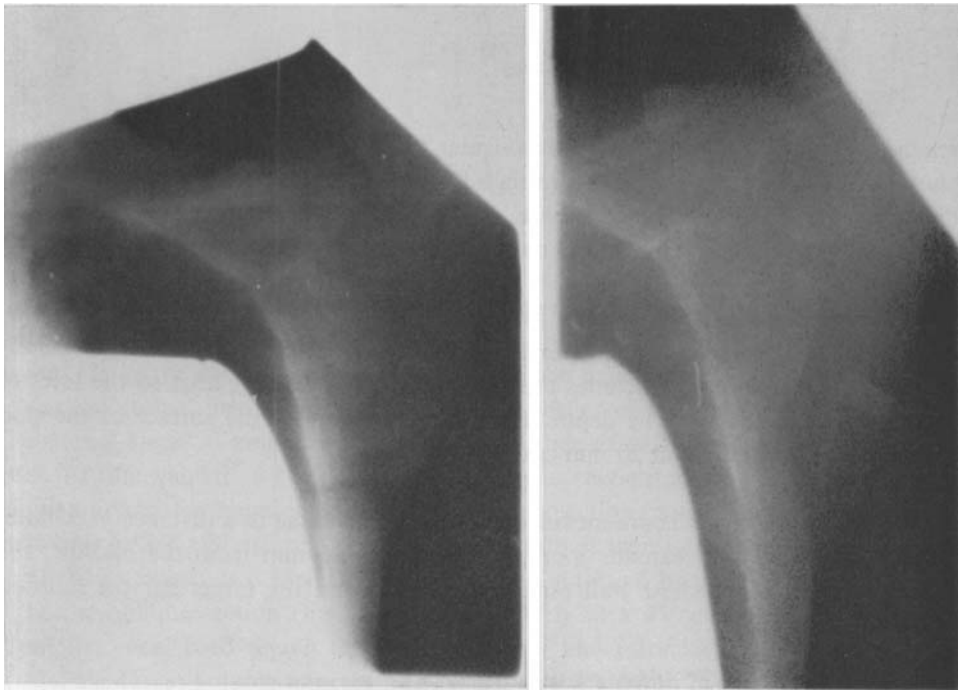
Specification of target absorbed dose

The specification of target absorbed doses agrees with those of ICRU Report 29 according to which 'the specification of target absorbed dose for reporting depends on the treatment technique ...'.



a b c d

Fig. 5. Examples of field arrangements.



a b

Fig. 6. Films during irradiation (6 MV roentgen rays, Linac, SSD 100 cm) of a) ventral and b) dorsal beam towards axilla and supra- and infraclavicular fossae (cf. Fig. 5 a, b).

Axilla and the infra- and supraclavicular fossae. This part of the target volume is irradiated (Fig. 5 a, b) with one large ventral beam towards the axilla, infra- and supraclavicular fossae and one smaller dorsal beam towards the axilla only, with beam directions 0° and 180°, respectively. A film of the ventral beam exposed during irradiation is demonstrated in Fig. 6, and the distribution of absorbed dose in the oblique section (cf. Fig. 1) appears in Fig. 7. ^{60}Co gamma rays or 5 to 6 MV roentgen rays (Linac) are used at SSD 80 to 100 cm. The weighting of the posterior beam aims at achieving the same absorbed dose in the two specification points, often it is 0.25

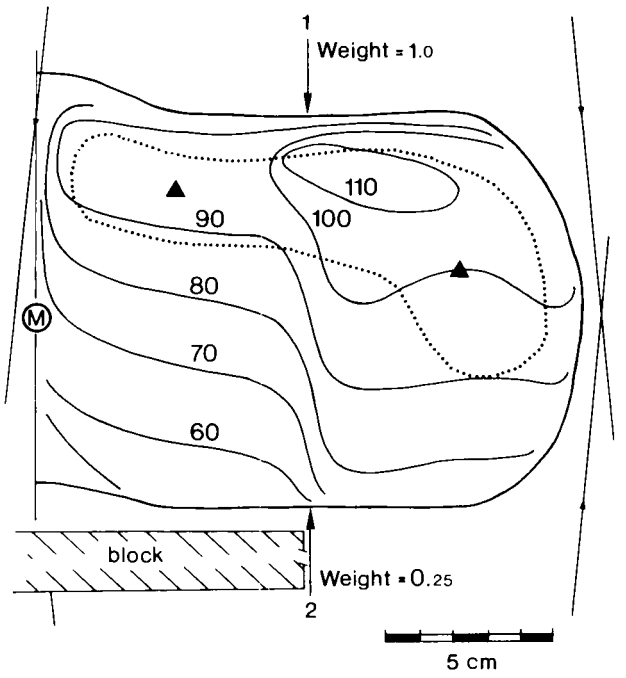


Fig. 7. Distribution of absorbed dose in oblique section through axilla and infra- and supraclavicular fossae (cf. Fig. 1). 6 MV roentgen rays (Linac), SSD 100 cm, field size 16 cm × 19 cm. No correction for tissue heterogeneity. When present, scar(s) are included in the target area as shown in Fig. 1. ... border of target area. ▲ dose specification point. M spinal cord.

of the anterior beam. The posterior beam is blocked along its medial surface. The patients are irradiated only in the supine position. Bolus is used only at scars and drainage exits.

For practical reasons, the most medial-caudal part of this part of the target volume is often irradiated together with the internal mammary nodes.

As stated, the medial part of the target volume in this region is irradiated by a single beam (the anterior beam), and the lateral part by 2 opposed coaxial unequally weighted beams. For both parts, the point at which the target absorbed dose is stated is at the centre of the target region (Figs 1, 7); this means at a depth of approximately 20 mm for the infra- and supraclavicular fossae and at a depth of one-third of the antero-posterior distance in the axilla, measured from the ventral skin surface.

The specified target absorbed dose is for the infra- and supraclavicular fossae 45 Gy and for the axilla 48 Gy. With this relation between the two, the minimum target absorbed dose will be the same for the infra- and supraclavicular fossae and for the axilla.

Internal mammary nodes are irradiated with a ventral electron beam (beam direction 0°) at SSD 100 cm (Fig. 5 c). The energy of the beam is chosen so that the 80 % isodose encloses the target volume (ICRU Report 29; Fig. 8). For the machines available at the participating departments this means that an electron energy of

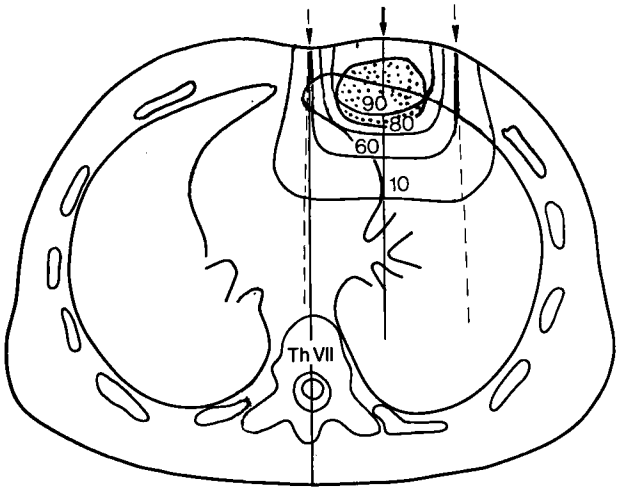


Fig. 8. Distribution of absorbed dose in transverse section for irradiation of internal mammary nodes. 15 MeV electrons, SSD 110 cm, maximum target absorbed dose 100 %, field size 6 cm × 14 cm. No correction for tissue heterogeneity. Dotted area indicates target volume. (Reproduced from ICRU Report 29, 1978; by courtesy of the publishers.)

15 MeV is suitable. The stated target absorbed dose is the maximum target absorbed dose (= 100 %).

The specified target absorbed dose for the internal mammary nodes is 48 Gy.

Chest wall. This part of the target volume is irradiated with one ventral beam (beam direction 0°) with conventional roentgen rays (120 kV, HVL 0.10–0.13 mm Cu) at SSD 60 cm (Fig. 5 d). The point at which the target absorbed dose is stated is in the middle of the target volume (= at a depth of 10 mm from the skin surface).

The specified target absorbed dose for the chest wall is 38 Gy, in muscle (reported with ^{60}Co gamma rays as reference, ICRU Report 29, Table 4.1). Alternatively, electrons may be used, then with bolus of the scar region.

Time-dose schedule

All fields are irradiated at each fraction, 5 fractions a week. Totally 20 fractions are given and the treatment is delivered in 2 series with 12 fractions in the first and an interval of 3 weeks between the 2 series. The total treatment period then amounts to 49 days. The reason for giving the treatment in 2 series is to diminish the skin reaction in the chest wall region. Previous experience (LINDGREN et coll. 1968) with 503 patients treated with split-course irradiation has shown the feasibility of this scheduling.

Absorbed dose to organs at risk

The total absorbed dose to the spinal cord must not exceed 42 Gy, and less in patients with impaired circulation, e.g. 30 Gy in the diabetic patient.

The peak absorbed dose to the chest wall target volume must not exceed 45 Gy.

The maximum target absorbed dose must not exceed a value that corresponds to a CRE-value of more than 1 850.

SUMMARY

A standardized programme for postoperative radiation therapy of carcinoma of the breast stage II is reported. The target volume and the organs at risk are defined, and the target absorbed dose and fractionation are specified. The irradiation technique is briefly described.

ZUSAMMENFASSUNG

Ein standardisiertes Programm für die postoperative Strahlentherapie des Brustkarzinoms Stadium II wird beschrieben. Das Targetvolumen und die kritischen Organe wurden definiert und die absorbierte Dosis im Target und die Fraktionierung spezifiziert. Die Bestrahlungstechnik wird kurz beschrieben.

RÉSUMÉ

Les auteurs présentent un programme standardisé pour le traitement post-opératoire par les radiations du carcinome du sein au stade 2. Ils définissent le volume cible et les organes exposés au risque d'irradiation et ils spécifient la dose absorbée à la cible et le fractionnement. Ils décrivent brièvement la technique d'irradiation.

REFERENCES

HULTBORN A., HULTÉN L., ROOS B., ROSENCRANTZ M., ROSENGREN B. and ÅHRÉN CH.: Topography of lymph drainage from mammary gland and hand to axillary lymph nodes. Acta radiol. Ther. Phys. Biol. 10 (1971), 65.

ICRU Report 29. Dose specification for reporting external beam therapy with photons and electrons. ICRU, Washington, D.C. 1978.

KETT K., VARGA G. and LUKÁCS L.: Direct lymphography of the breast. Lymphology 1 (1970), 3.

LINDGREN M., BORGSTRÖM S. and LANDBERG T.: Pre-operative radiotherapy in operable breast cancer. *In:* Prognostic factors in breast cancer, p. 103. Edited by A. P. M. Forrest and P. B. Kunkler. Livingstone, Edinburgh and London 1968.

RAGNHULT I., LINDSKOUG B. and HULTBORN A.: Dosimetric investigation of post-operative irradiation of regional lymph nodes in mammary carcinoma. Acta radiol. (1972) Suppl. No. 313, p. 135.

STIBBE E.: The internal mammary lymphatic glands. J. Anat. 52 (1918), 257.

WEISENBURGER T. H. and JUILLARD G. J. F.: Upper extremity lymphangiography in the radiation therapy of lymphomas and carcinoma of the breast. Radiology 122 (1977), 227.