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EN-BLOC IRRADIATION OF TUMOURS OF THE HEAD AND NECK AND THEIR LYMPHATICS

I. Technique and dosimetry

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In the treatment of malignant tumours of the head and neck uncontrolled metastatic disease in the cervical lymph nodes has become a major cause of treatment failure, since with improvements in radiation technique the primary tumour is now more often cured.

The topographic position of the cervical lymph nodes in health and disease has been demonstrated by FISCH (1968). In the normal cervical lymphogram the posterior border of the lymph node chain is superimposed upon the spinal processes of the cervical vertebrae, and the nodes are thus situated posteriorly to the cervical spinal cord. In case of metastatic node disease or after surgery they may be located still more posteriorly, and then also the contralateral nodes may be filled.

The frequency of different neck node involvements at presentation for different tumours of the head and neck has been demonstrated by FLETCHER et coll. (1973). In their series the posterior cervical lymph nodes were most often involved when the primary tumour was located in the tonsillar fossa, base of the tongue, oropharyngeal walls, nasopharynx, and hypopharynx, but less often when the primary tumour was located in the oral tongue, floor of the mouth, retromolar trigone, anterior faucial pillar, soft palate, or supraglottic larynx.

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If it is desired to include in the target not only the primary tumour but also the lymphatics on both sides of the neck in the curative treatment of tumours of the head and neck, the cervial spinal cord presents a dilemma, since the absorbed dose often aimed at in the target equals or exceeds the cord tolerance. In gross metastatic disease in the neck this is usually the case; in only microscopic deposits in the cervical lymph nodes a smaller absorbed dose may be sufficient. However, subclinical disease may not always be the same as microscopic disease.

Precise data on the radiation tolerance of the spinal cord are lacking. It seems that several factors are of importance. Such are the relative size of the irradiated volume (BODEN 1950, BERG & LINDGREN 1963), the condition of the vascular supply of the cord (ASSCHER & ANSON 1962), the total absorbed dose in the cord and the type of fractionation used. Most reports indicate that the threshold value for radiation myelitis is of the order of 3 900 rad given over 4 weeks (BODEN, PALLIS et coll. 1961, PHILLIPS & BUSCHKE 1969). The radiation sensitivity of the spinal cord seems to be time-dependant with a slope of the time-dose line of the order of 0.26 (LINDGREN 1958) to 0.21 (PALLIS et coll.). Relatively large absorbed doses may then be tolerated if the treatment extends over a long period of time, provided that the absorbed dose at each fraction be not too large (ATKINS & TRETTER 1966, PHILLIPS & BUSCHKE). In the therapy of malignant lymphoma, this may be useful, but in the therapy of epithelial tumours, prolongation of total treatment time and number of fractions can not be used to the same extent.

BAEKMARK (1975) reported on neurologic complications after irradiation of the cervical spinal cord in the treatment of malignant tumours of the head and neck. Myelopathy was observed in 7 per cent of the patients. Patients who also received chemotherapy with Vincristine had a higher frequency (30 per cent) of myelopathy. Most of the patients with myelopathy had received a cord dose in the range 3 000 to 3 900 rad given with 1 000 rad per week, but some patients had received larger absorbed doses. BAEKMARK stated that 'an attempt to avoid including the spinal cord in the irradiation involves a risk of underdosage of tumour-affected area; this has to be weighed against the risk of producing radiation myelitis'.

If in the irradiation of malignant epithelial tumours in the region of the head and neck, lateral opposed ports are used to include the cervical lymph nodes, the ports have to be reduced towards the end of treatment to save the cord, and additional measures have to be taken to obtain optimum cure rate. Such measures may be the addition of tangential fields to avoid the cord, boost therapy with electrons or implants, or surgery. Alternatively may also from the very beginning a more complicated technique be used. RUBIN & KELLER (1975) described different techniques used in laryngeal carcinoma, and reported for instance a technique with two posterior oblique fields with wedges and compensators to include the cervical nodes.

The purpose of the present communication is to report a radiation technique for malignant tumours in the region of the head and neck which allows for en-bloc irradiation of the primary tumour and all cervical lymph nodes from the tip of the

mastoid down including those in the supraclavicular fossa as well as the retropharyngeal nodes, without exceeding the tolerance of the spinal cord. In this Department it is considered desirable not to exceed 4 200 rad for ^{60}Co γ-rays in the cord when given in 20 fractions over 4 weeks.

Side effects and early results will be reported in a later communication.

Method

The patient is first positioned (Fig. 1) under fluoroscopy to get the cervical and upper thoracic spinal cord as straight as possible. It is an advantage if the cord is also horizontal, but usually this is not possible to achieve, and the straightened cord often forms an angle with the horizontal plane of the order 15 to 30 degrees. The position of the patient is defined by cutting a silhouette cardboard to fit the patient (Fig. 1).

The patient is then transferred to the mould room and positioned properly with the help of the silhouette cardboard. A dorsal plastic cast (Fig. 2) is produced, which extends from above the vertex to the level of the 7th thoracic vertebra.

Patient contours perpendicular to the spinal cord are then obtained at representative levels. In a patient with a nasopharyngeal tumour five different contours are drawn (Fig. 3), viz. at the levels of: I nasopharynx, II tip of the mastoid, III submaxillary region, IV vocal cords, and V jugulum. In a patient with a tumour of the hypopharynx, only contours III, IV and V are drawn. A.p. and lateral films of known magnification are exposed, and the position of the tumour, target area, tissues of interest, and reference points are indicated in the contours.

The irradiation is administered (Fig. 4) through one ventral field (No. 1) and 2 dorsal oblique wedged fields (Nos 2 and 3), all fields being oriented in a plane perpendicular to the cord. If the nasopharynx is to be irradiated, lateral opposed fields with different weighing above and below the upper borders of fields 2 and 3 are used (fields 4 to 7, Fig. 4). The lower border of fields Nos 4 and 5 match the upper border of field No. 1. Fields Nos 1, 2 and 3 are treated with ^{60}Co at SSD 70 to 90 cm, whereas fields Nos 4 to 7 are treated with 8 MV roentgen radiation at SSD 100 cm. The dose planning is performed individually for each patient. Often the beam orientation of the posterior fields is 135 and 225 degrees from the direction of the ventral field, and they often receive 50 per cent of the peak absorbed dose of the ventral field. In order to compensate for the relatively large absorbed dose in the midline from the dorsal fields or to diminish the absorbed dose in the spinal cord from the ventral field, different beam compensating filters are available for the ventral field. The choice of filter depends among other things on whether there is tumour in the midline or not.

The dose plan in three different sections for a patient with tumour of the hypopharynx appears in Fig. 5. Tumour (marked in black) is only found in the neck region, section IV (Fig. 5 b). The target area which besides the tumour includes the lymph

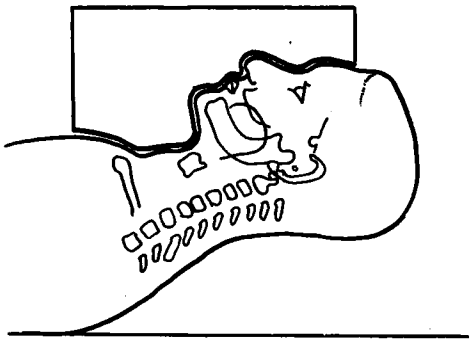


Fig. 1

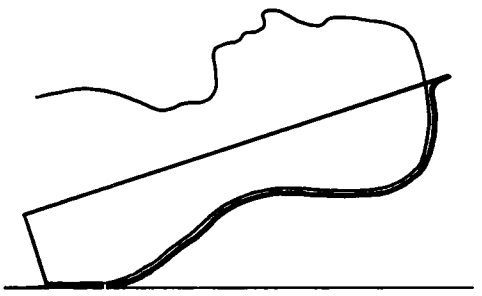


Fig. 2

Fig. 1. Positioning of the patient under fluoroscopy to obtain the spinal cord as straight as possible. The position is defined by cutting a silhouette cardboard.

Fig. 2. Plastic cast used to immobilize the patient.

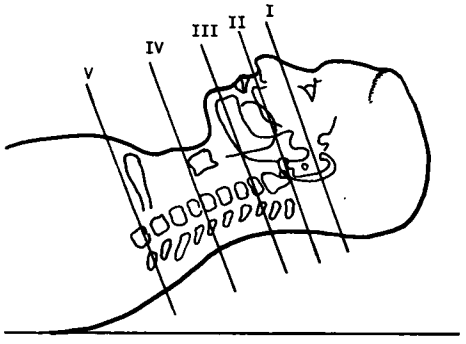


Fig. 3

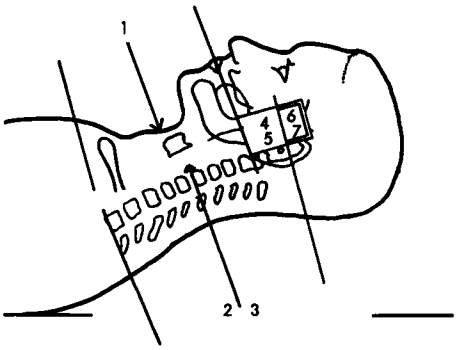


Fig. 4

Fig. 3. Cross-sections for dose planning in a patient with carcinoma of the nasopharynx. In a carcinoma of the hypopharynx, where the nasopharynx is not to be treated, only sections III, IV and V are drawn.

Fig. 4. Field arrangement in a patient with carcinoma of the nasopharynx. In a carcinoma of the hypopharynx, where the nasopharynx is not be treated, fields 2 and 3 share cranial border with field 1.

nodes from the tip of the mastoid down to those in the supraclavicular fossa is indicated by the honeycombed area. The vertebrae and the spinal cord are indicated from the films. Further, the films demonstrate how the cross sections will be superimposed, an information necessary for the dose planning.

The collimating system of the Gammatron I used for most of these irradiations is of the block type allowing for irregular fields (Fig. 7 a). The center of the field does not necessarily have to coincide with the central beam (Fig. 7 c), which may be advantageous when defining the SSD. The field sizes are given by the number of opened lamellaelements and explains the decimal in the field-sizes shown in the Figures.

The dose planning is carried out with a computer (MÖLLER et coll. 1976). The

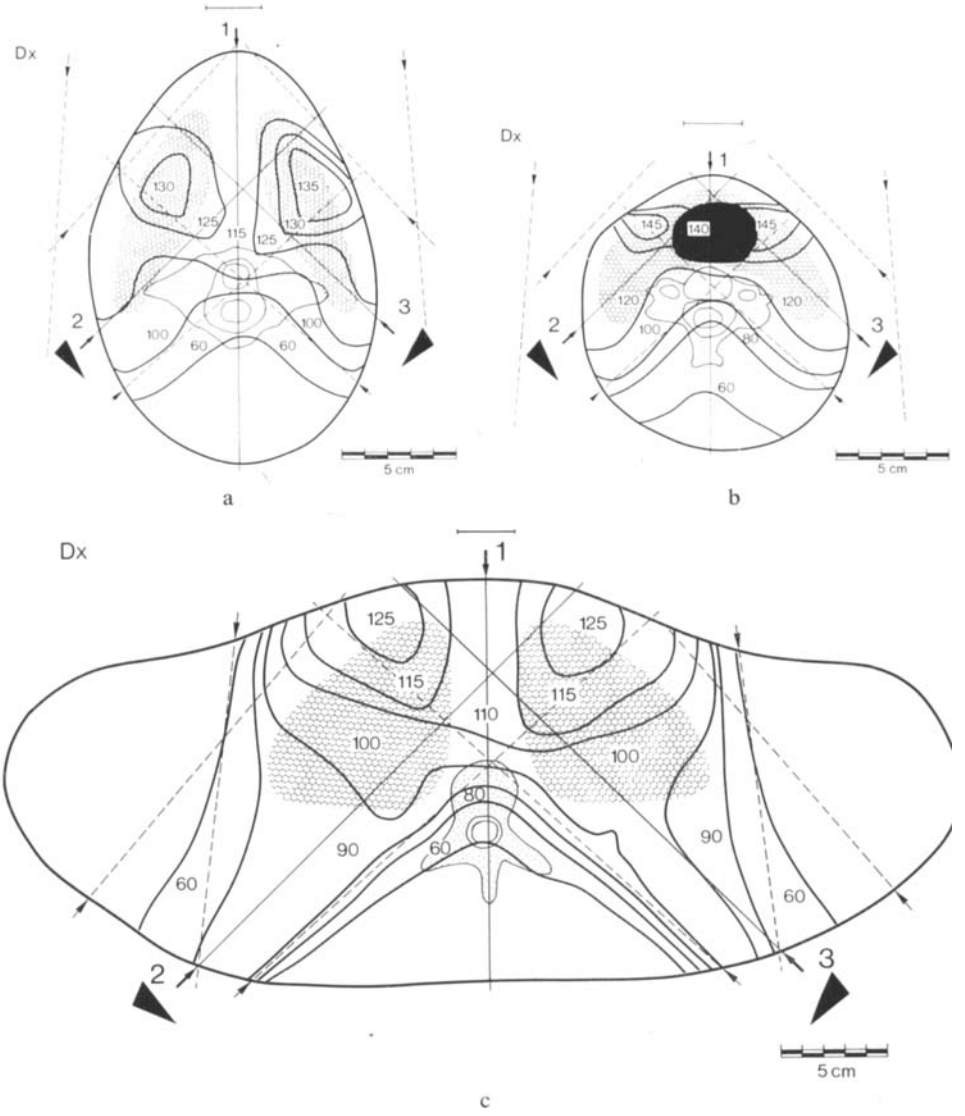


Fig. 5. Carcinoma of the hypopharynx. Dose plan for ^{60}Co irradiation a) section III (honeycombed area: target), b) section IV (black area: tumour) and c) section V. a) Field 1: 90 cm SSD, 100 %, 15.4 cm × 17.6 cm, compensating filter of 4 mm copper. Fields 2 and 3: 70 cm SSD, 50 %, 6.7 × 16.2 cm, 45° wedge filter. b) Field 1: same as in a. Fields 2 and 3: 70 cm SSD, 50 %, 5.4 cm × 16.2 cm, 45° wedge filter. c) Field 1: same as in a. Fields 2 and 3: 70 cm SSD, 50 %, 9.4 cm × 16.2 cm, 45° wedge filter.

SSD is put to the cross section in the neck region. In the submaxillary and jugular cross sections (No III and V) correction is done to the real SSD which is smaller in these sections than in the neck section. Specially measured isodose charts are used for the submaxillary and jugular sections taking into regard the somewhat smaller

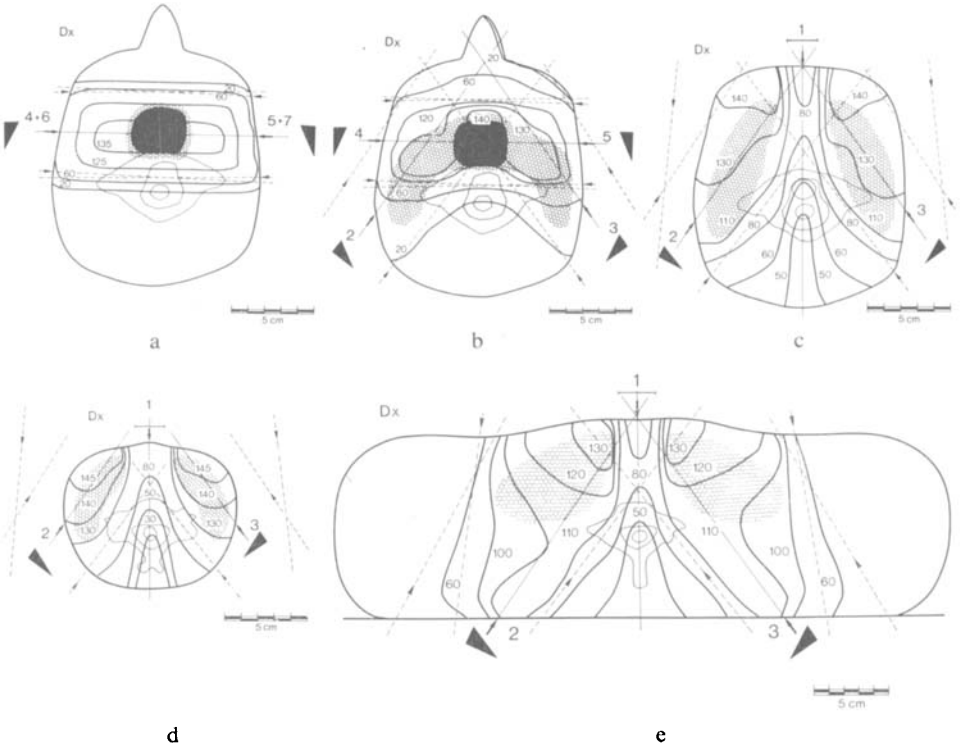


Fig. 6. Carcinoma of the nasopharynx. Dose plan for a) section I, b) section II, c) section III, d) section IV and e) section V. a) 8 MV, 100 cm SSD. Fields 4 and 5: 50 %, 5 cm × 6 cm, 15° wedge filter. Fields 6 and 7: 30 %, 5 cm × 6 cm, no wedge filter. b) Fields 4 and 5: 8 MV, 100 cm SSD, 50 %, 5 cm × 6 cm, 15° wedge filter. Fields 2 and 3: ^{60}Co 70 cm SSD, 50 %, 5.4 cm × 18.9 cm, 45° wedge filter. c) Field 1: ^{60}Co 90 cm SSD, 100 %, 15.4 cm × 15.4 cm, compensating filter of 60 mm lead. Fields 2 and 3: ^{60}Co 70 cm SSD, 50 %, 5.4 cm × 18.9 cm, 45° wedge filter. d) Field 1: same as in c. Fields 2 and 3: ^{60}Co 70 cm SSD, 50 %, 5.4 cm × 18.9 cm, 45° wedge filter. e) Field 1: same as in c. Fields 2 and 3: same as in d.

depth dose near the field edges in an elongated ^{60}Co field compared with the depth dose in the central ray. Corrections are made for the vertebrae in the dose plans. The peak absorbed dose of the ventral field is 100 per cent, and it is filtered in the treatment illustrated in Fig. 5 with 4 mm Cu in the central part. The dorsal oblique fields have 50 per cent peak absorbed dose and 45° wedge filters. The broken lines indicate the geometrical edges of the fields. In the dose plans the figures are written on the larger dose side of the isodose lines. No contour compensating filters are used, and because of the higher per cent target dose in the neck region the fields have to be blocked in the neck region towards the end of treatment to level the absorbed dose in the whole target volume.

The dose plans for a patient with tumour of the nasopharynx appear in Fig. 6. For the sections through the submaxillary region, the neck and the jugulum (Fig. 6 c, d, e) the technique is the same as previously demonstrated for a patient with

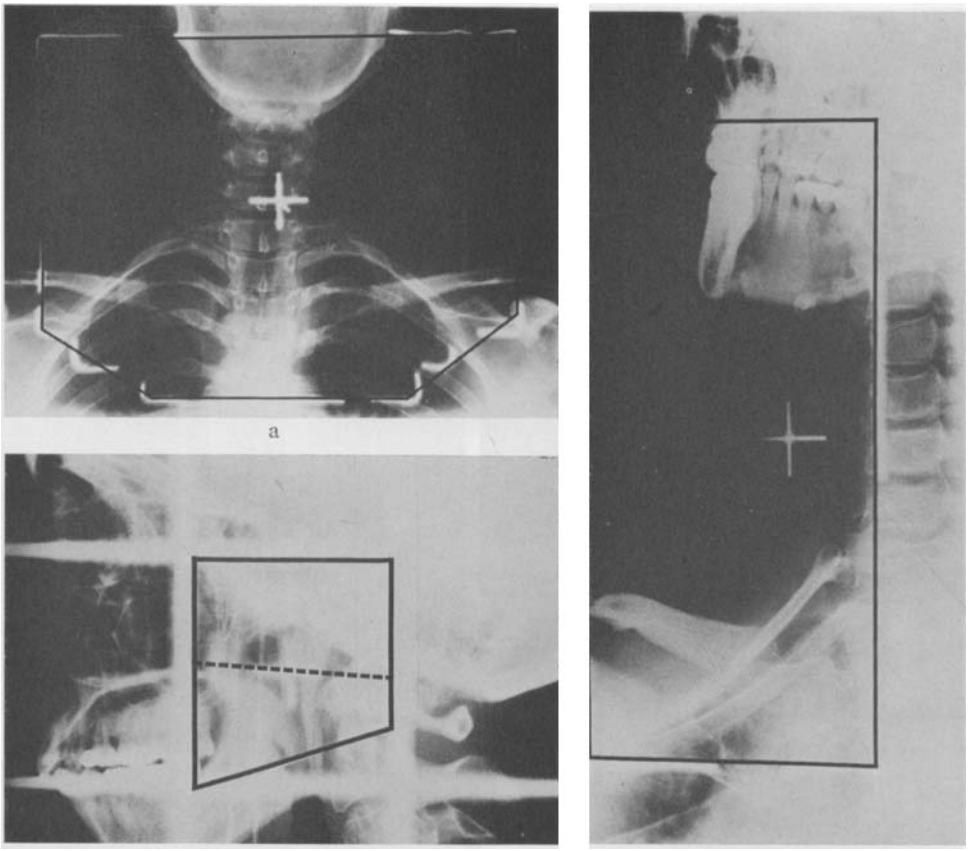
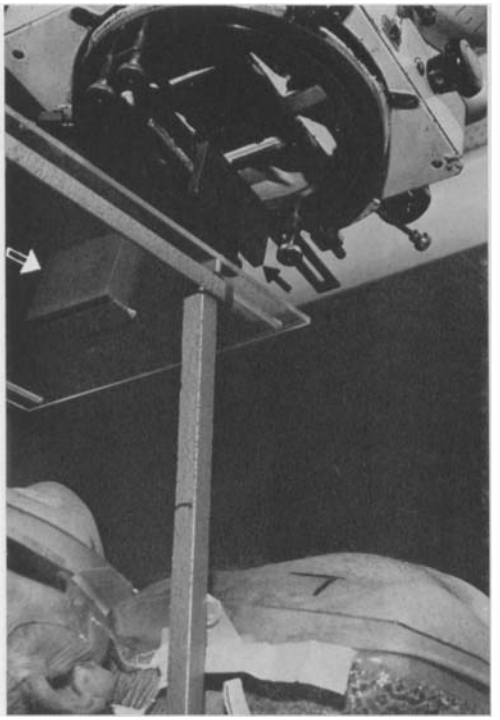
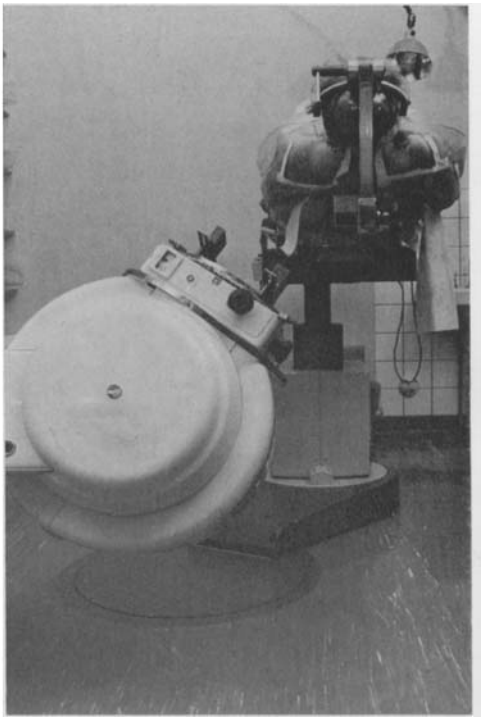


Fig. 7. Carcinoma of the nasopharynx. Portal films of a) field 1, b) fields 5 and 7, and c) field 3.

carcinoma of the hypopharynx, except for a 60 mm lead filter now being used in the ventral field instead of the copper filter. The ventral field and the dorsal oblique fields end at different levels (Fig. 4) and the caudal part of the nasopharynx is treated with the two dorsal oblique fields with 50 per cent peak absorbed dose and with two opposed wedged fields irradiated with 8 MV roentgen rays with 50 per cent field dose (Fig. 6 b). Finally, the most cranial part of the target, that is the upper part of the nasopharynx and the base of the skull, is treated with two opposed wedged fields with peak absorbed dose 50 per cent and two opposed fields without wedges and with peak absorbed dose 30 per cent (Fig. 6 a), all fields irradiated with 8 MV roentgen rays. It is an advantage if the fields join at different levels, since this will reduce junction problems. It must be realized that the nodes that are situated dorsally and cranially to the mastoid are only treated from the dorsal oblique fields, and thus receive a small absorbed dose. They are usually not included in the target, but have been so in Fig. 6 b in order to emphasize this point. The peak absorbed doses 50



a



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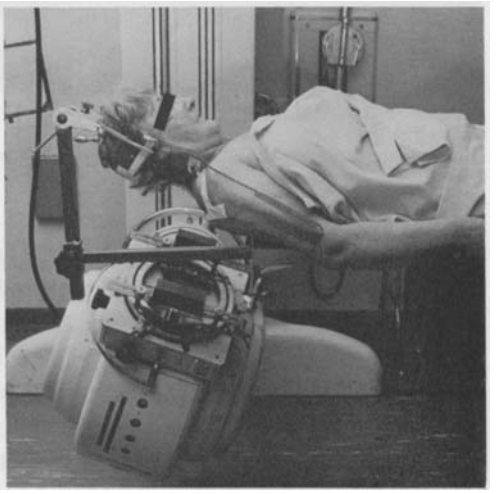


c

Fig. 8. a) Treatment set up for field 1 in a patient with metastatic disease from a previously irradiated carcinoma of the lower lip. Patient supine, lying in the cast. Beam compensating filter of lead (black arrow). Shield for the lower lip (white arrow). b) Set up for field 3. All fields are irradiated with the patient in the same position. c) Set up for field 2. The central beam is perpendicular to the cord.

and 30 per cent for the fields irradiated with 8 MV roentgen rays have been chosen to give the same target absorbed dose in the base of the skull, nasopharynx, and submaxillary region. Also in this type of treatment the neck has to be shielded towards the end of the treatment course.

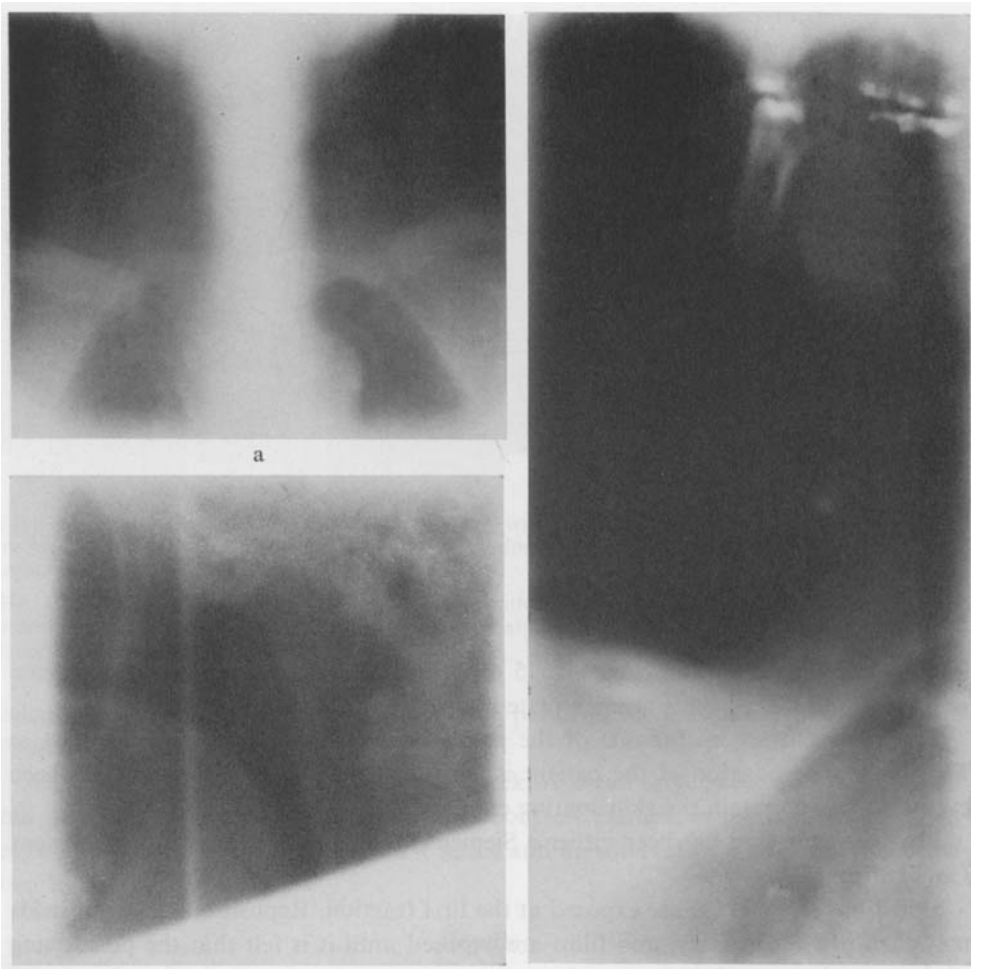


Fig. 9. Carcinoma of the nasopharynx. a) Film of field 1. The beam compensating filter of lead is clearly visible. b) Fields 5 and 7. c) Field 3.

The beam entrances and geometrical edges of the fields are localized on the patient under fluoroscopy and drawn on the patient and on the cast. Films of the ports are obtained and corrections, if indicated, are performed. Representative portal films for a patient with carcinoma of the nasopharynx are demonstrated in Fig. 7.

The treatment set up for the ventral field appears in Fig. 8 a. The central beam is directed perpendicular to the spinal cord, and the field therefore has to be tilted, in this case about 15 degrees. The beam compensating filter is seen just under the collimator; there was no target in the midline and therefore a thick compensating filter was used. Because of previous irradiation towards this region, a shield for the

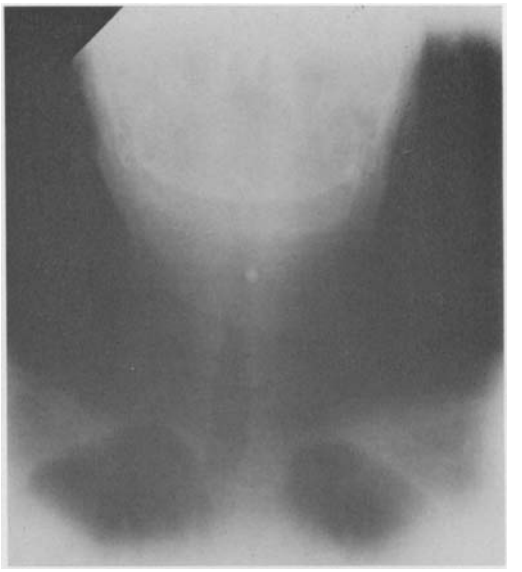


Fig. 10. Carcinoma of the hypopharynx. Film of field 1. The beam compensating filter of copper is not recognizable.

lower lip was used. It consisted of a 5 cm thick lead block, cut to suit the beam geometry, and placed on a perspex plate about 20 cm above the patient.

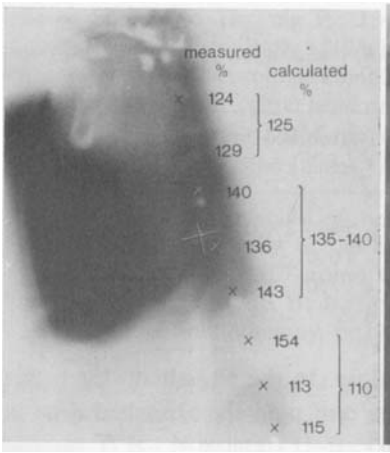
The treatment set up for one of the posterior oblique fields (No. 3) appears in Fig. 8 b, c. The position of the patient is the same for all fields. Windows have been cut in the cast to retain the skin sparing effect of the ^{60}Co γ-rays.

The ^{60}Co unit used has been either a Siemens Gammatron I (Fig. 8) or a Siemens Gammatron III.

Slow films (Figs 9, 10) are exposed at the first fraction. Repositioning of the fields may then prove necessary, and films are exposed until it is felt that the positioning of the ports is correctly reproduced.

For each field the peak absorbed dose is determined at the first fraction with a cable connected ionization chamber. The absorbed dose at the eyes is determined either with small ionization chambers or with TLD frequently during the whole course of treatment to control the dose to the eyes, which may be critical due to maladjustment of the posterior fields.

As soon as the films agree with the dose plan and the treatment set up, the absorbed dose in the nasopharynx, mouth, pharynx and hypopharynx is determined using small ionization chambers placed in plastic catheters together with indicators and then inserted. Each measurement is repeated at least once. Examples of films obtained during fractions when such measurements were carried out appear in Figs 11 and 12. The position of the different measuring points is defined by the indicators. The measured values for absorbed dose as well as the calculated values according to the dose plans are also indicated. If there is a difference between the measured and



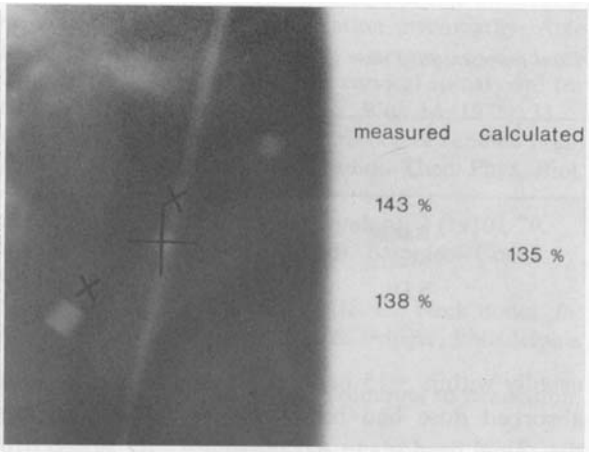


Fig. 11 Fig. 12

Fig. 11. Film of field 3. Position of plastic catheters with 8 ionization chambers and lead indicators in the hypopharynx. Measured values for absorbed dose to the left and calculated values according to the dose plan to the right.

Fig. 12. Film of fields 5 and 7. Position of plastic catheters with two ionization chambers and lead indicators in the nasopharynx. Measured values for absorbed dose to the left and calculated values according to the dose plan to the right.

calculated absorbed doses in excess of 6 to 8 per cent, the reason must be sought for (MÖLLER et coll.).

All fields are irradiated daily 5 days a week. A mean target absorbed dose of 200 rad per fraction is aimed at. Usually split course treatment is used with two thirds of the total absorbed dose in the first series and an interval of 4 weeks between the two series.

Results

The treatment charts for 68 consecutively treated patients were reviewed (Tables 1, 2). The minimum absorbed dose in the tumour was taken as the representative dose (=100 per cent). The maximum and the minimum target absorbed doses were

Table 1

Variation in total absorbed dose in the target and in the spinal cord in relation to the representative dose (in per cent)

	Maximum target dose	Representative dose = minimum absorbed dose in tumour	Minimum target dose	Absorbed dose in the spinal cord
Range	145–105	100	100–70	90–50
Mean	115		85	70
S.D.	7		6	9

Table 2

Total representative dose (= minimum absorbed dose in tumour) and absorbed dose in the spinal cord- in 68 patients

	Representative dose	Absorbed dose in the spinal cord
Range	6 500–4 200 rad	5 600–2 400 rad
Mean	5 800	4 000
S.D.	575	550

usually within ±15 per cent of the representative dose. In the 68 patients the target absorbed dose had been mean 5 800 rad ±15 per cent, and the absorbed dose in the spinal cord mean 4 000 rad.

When starting a new technique of such a complex nature as the one described, certain problems of technical nature are to be expected. Such were also encountered in the first patients treated, but proved to be possible to overcome. It is very important that the positioning of the patient is well defined and reproduceable at each fraction. Also the anatomic planning should be very carefully performed. The technique has now proved to be feasible for clinical routine, and it is at present the standard method for treating tumours of the head and neck and their lymphatics. In order to achieve optimum results, repeat control measures and a close surveillance of the irradiation by the therapist and the physicist in close cooperation is necessary.

SUMMARY

A technique for en-bloc irradiation of tumours of the head and neck and their lymphatics, as well as its dosimetry and control measures, are reported.

ZUSAMMENFASSUNG

Eine Technik zur En-bloc-Bestrahlung von Kopf- und Nacken-Tumoren und deren Lymphknoten sowie die zugehörige Dosimetrie und die Kontrollmessungen werden beschrieben.

RÉSUMÉ

Présentation d'une technique pour l'irradiation en bloc de la tête et des tumeurs du cou et de leurs lymphatiques et présentation de la dosimétrie et des mesures de contrôle de cette technique.

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