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MANTLE TREATMENT OF HODGKIN'S DISEASE

Results and side effects

GUDRUN SVAHN-TAPPER, L. BALDETORP and T. LANDBERG

The rationality of irradiation not only of involved but also of adjacent, clinically apparently uninvolved lymph node groups in patients with localized Hodgkin's disease has been stressed by PETERS (1950, 1966), PETERS & MIDDLEMISS (1958), KAPLAN (1962, 1966), SALZMAN et coll. (1964), JELLIFFE (1965), NOBLER (1968), and others.

In recent years the mantle technique has been widely used in the treatment of supradiaphragmatic disease. The recommended absorbed dose in the target is usually about 40 Gy (4 000 rad) in 4 weeks, or the treatment is given in split-course with a rest interval (LANDBERG & FORSLO 1970, LANDBERG et coll. 1971, JOHNSON et coll. 1971, LANDBERG et coll. 1973, FAZEKAS et coll. 1975).

It still remains to be demonstrated if extended-field treatment is superior to involved-field treatment in Hodgkin's disease. Prospective trials have not demonstrated any definite superiority of either method (NICKSON & HUTCHISON 1972). Further, it remains unclear whether involved-field radiation therapy in combination with chemotherapy may prove superior to extended-field therapy in localized Hodgkin's disease (ROSENBERG & KAPLAN 1975).

Since extended-field radiation therapy may carry a higher morbidity and even

From the Departments of Radiation Physics (Director: Prof. K. Lidén) and Radiation Therapy (Director: Prof. M. Lindgren), the University Hospital, S-221 85 Lund, Sweden. Supported by grants from the Swedish Cancer Society. Submitted for publication 9 February 1976.

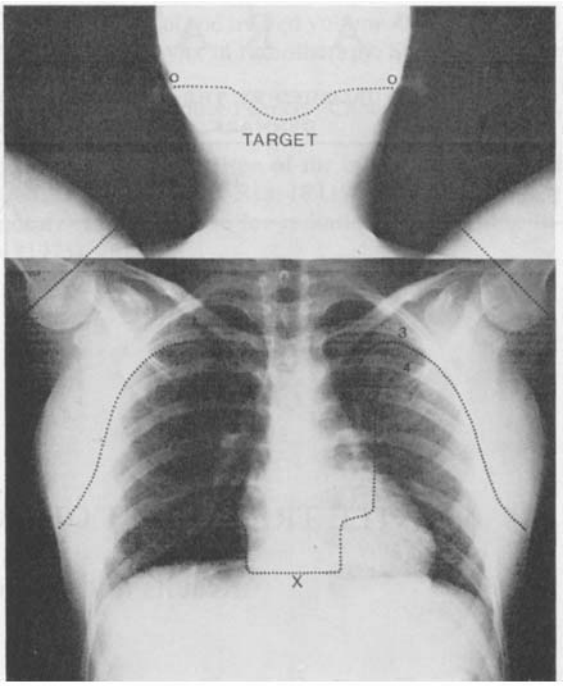


Fig. 1. Example of target volume in the mantle treatment of Hodgkin's disease. The minimum size of the target in the hilar region is 8–10 cm × 8–10 cm. O = external auditory canal; × = tenth thoracic vertebra; 3 and 4 = third and fourth rib, respectively; ····· = border of the target.

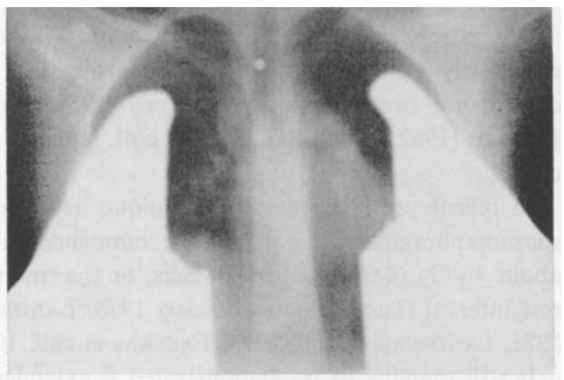


Fig. 2. Example of slow film exposed during mantle treatment of Hodgkin's disease.

mortality than involved-field therapy, the superiority, if any, of the former method compared with the latter may be outweighed by side effects.

In 1971 a preliminary report was given of side effects and early results of mantle treatment for Hodgkin's disease from these departments (LANDBERG et coll.), and in 1972 a report on the radiation sensitivity of tissues irradiated during mantle treatment of Hodgkin's disease was given (LANDBERG et coll.).

The purpose of the present communication is to report results and side effects in a larger group of patients, including the previous materials.

Material and Methods

The material consisted of 90 patients with supradiaphragmatic Hodgkin's disease, stages I, II, or III A, treated with the mantle technique or total nodal irradiation from 1967 to 1974.

The staging procedures included as a rule lymphography, scintigraphy and percutaneous fine needle aspiration biopsy of the liver and spleen, bone marrow examination (aspiration or biopsy), chest films, and from 1971 staging laparotomy with splenectomy.

In the mantle treatment the border of the target (Fig. 1) is defined with the patient in treatment position at least as follows: the cranial border is at the caudal border of the external auditory canals and includes the submaxillary and the submental nodes. In the axillae two thirds of the humeral heads are included (the patients are treated with their arms raised) and medially the target follows the caudal border of the third rib. The position of the axillary lymph nodes in a patient with raised arms has been demonstrated by KETT et coll. (1970), GRANT et coll. (1973) and WEISENBURGER & JUILLARD (1974). One centimeter below the clavicle is included. The mediastinum is included in the mantle to the middle of the tenth vertebra, since this is usually a region where few lymph nodes are found, and thus it is a level where a gap to an abdominal field may be placed with reasonable safety. In the hilar regions the target comprises a rectangular area of 8–10 cm × 8–10 cm. This definition of the target in the hilar region agrees with the statements given by HOVELACQUE et coll. (1938), ROY-CAMILLE (1959), SARRAZIN et coll. (1965), TAKAHASHI (1969) and with personal experience of the present authors in the postmortem room. Furthermore, the definition refers to a patient without bulky disease. If the patient is not safely immobilized during treatment, additional margins have to be added to the target.

The irradiations were given with ^{60}Co at SSD 130 cm and with the field 1 cm outside the target area blocked near the patient. The patients were irradiated in both supine and prone positions, and they were immobilized in large, individual casts, one for each position. These casts immobilized the patients from the vertex to the middle of the femora and they were made to minimize changes in patient contour upon change in position from supine to prone and vice versa.

Individual dose plans including correction for tissue heterogeneity were made for each patient, and measurements of absorbed dose in or at the patients were performed generously. Data on the technique have been presented previously (SVAHN-TAPPER 1970, 1976, SVAHN-TAPPER & LANDBERG 1971 and LANDBERG & SVAHN-TAPPER 1976). The correction for lung tissue was made according to SVAHN-TAPPER & LANDBERG and the fields were accordingly diminished over the hilar regions towards the end of treatment. This was not performed in the first 10 patients treated, and these 10 thus received a relatively large absorbed dose in the hilar regions.

A typical example of a slow film exposed during treatment appears in Fig. 2.

An absorbed dose of 40 Gy (4 000 rad) in the target, confirmed by in vivo measurements, and delivered with 5 fractions per week was aimed at. Usually the target absorbed dose per fraction was of the order of 1.5 Gy (150 rad) and as a rule split-course treatment was used with two thirds of the total absorbed dose in the first series and an interval of 4 weeks between the two series. Thus 40 Gy in 27 fractions over 71 days was usually given.

In the present material 2 fields were irradiated per fraction in 27 patients, 1 field per fraction in 53 patients and in 10 patients 1 field was irradiated per fraction for approximately half of the total course and 2 fields per fraction during the remaining course. The reason for this was varying patient load on the treatment apparatus.

After end of treatment the patients were seen regularly. In case of complete remission no chemotherapy was given, and the patients were seen every third month the first year, every fourth month the second year, and then twice a year. The follow-up examinations included chest films.

At review of the patients' charts special attention was focused on relapsing disease or side effects of the irradiation in the lungs, heart and pericardium, or spinal cord.

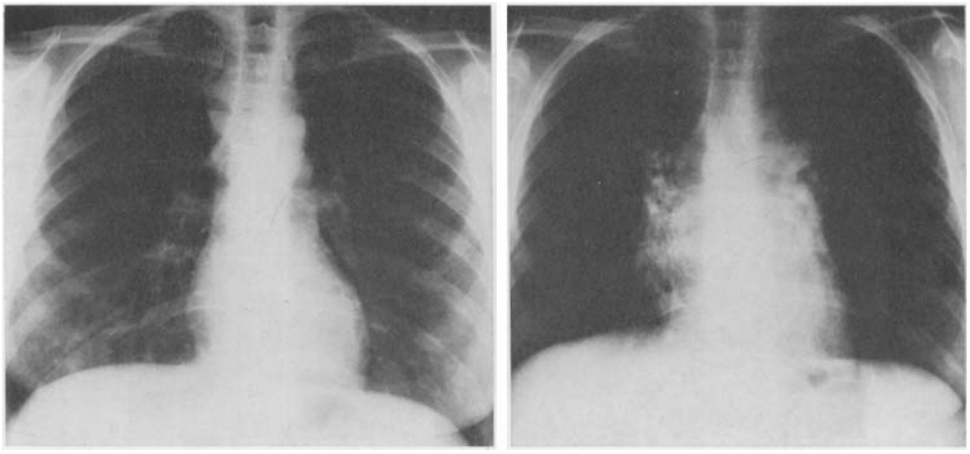
As suggested by KAPLAN (1966), local recurrence may be either a true recurrence or a marginal recurrence, being the first new sign of disease after primary treatment, whereas extension means a new manifestation of disease outside the irradiated tissues.

When evaluating the side effects of mantle treatment, symptoms or signs found 1, 3, and 6 months or more after the beginning of therapy were noted. Patients were considered evaluable only if they had a follow-up of at least 6 months. Only patients treated with split-course therapy were included. Symptoms and signs of radiation reactions in the lung parenchyma, heart and pericardium, and spinal cord as a rule showed a 'peak reaction' and then gradually improved. In the analysis, the peak reaction was recorded as the representative one.

Some patients had no symptoms of radiation pneumonitis, but in some of these, slight abnormalities were found on chest films. Other patients had moderate symptoms of radiation pneumonitis (slight cough, slight fever) which were not considered so severe as to merit specific therapy; or moderate abnormalities on chest films (Fig. 3). This figure illustrates a typical reaction of moderate degree following mantle treatment. In still other patients severe symptoms of radiation pneumonitis occurred, necessitating therapy with broad spectrum antibiotics and steroids, and with marked pulmonary abnormalities on chest films.

For each patient the maximum absorbed dose in the midplane of the hilar regions was calculated, i.e. the region where radiation pneumonitis was most extensive on chest films.

The doses were corrected for lung tissue using the diagram published by SVAHN-TAPPER & LANDBERG. The Cumulative Radiation Effect (CRE) value was calculated with gap correction both according to the formula:



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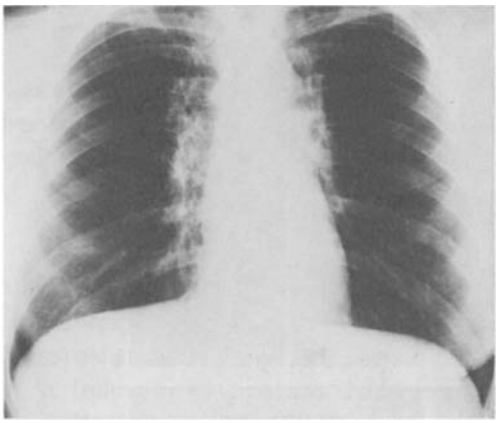

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Fig. 3. Radiation reactions after mantle treatment. a) Chest film before beginning of treatment. Mediastinal lymphadenopathy to the right. No hilar lymphadenopathy and no parenchymal abnormalities. b) Three months after the beginning of treatment. Complete regression of the mediastinal lymphadenopathy. Bilaterally in the lung parenchyma and especially in the hilar regions radiation pneumonitis. Its topography coincides with the shape of the mantle field in the hilar regions. c) Eighteen months after the beginning of treatment. Marked fibrosis and contraction in the perihilar tissue, previously the site of radiation pneumonitis, later found to be permanent.

$$\gamma_1(G) = \left(\frac{T+G}{T}\right)^{-0.11}$$

(WINSTON et coll. 1969) where $\gamma(G)$ = fractional decay of the CRE during the gap, G is the gap-time in days, and T is the time in days for the first series (course) of treatment, and according to the formula:

$$\gamma_2(G) = e^{-0.008\,G}$$

(KIRK et coll. 1975).

In some patients abnormalities in the heart and pericardium were observed, which were considered to be compatible with radiation reactions. Usually they did not give any symptoms, and only appeared on chest films (Fig. 4). For the heart and pericardium the absorbed dose at a depth of one third of the antero-posterior distance

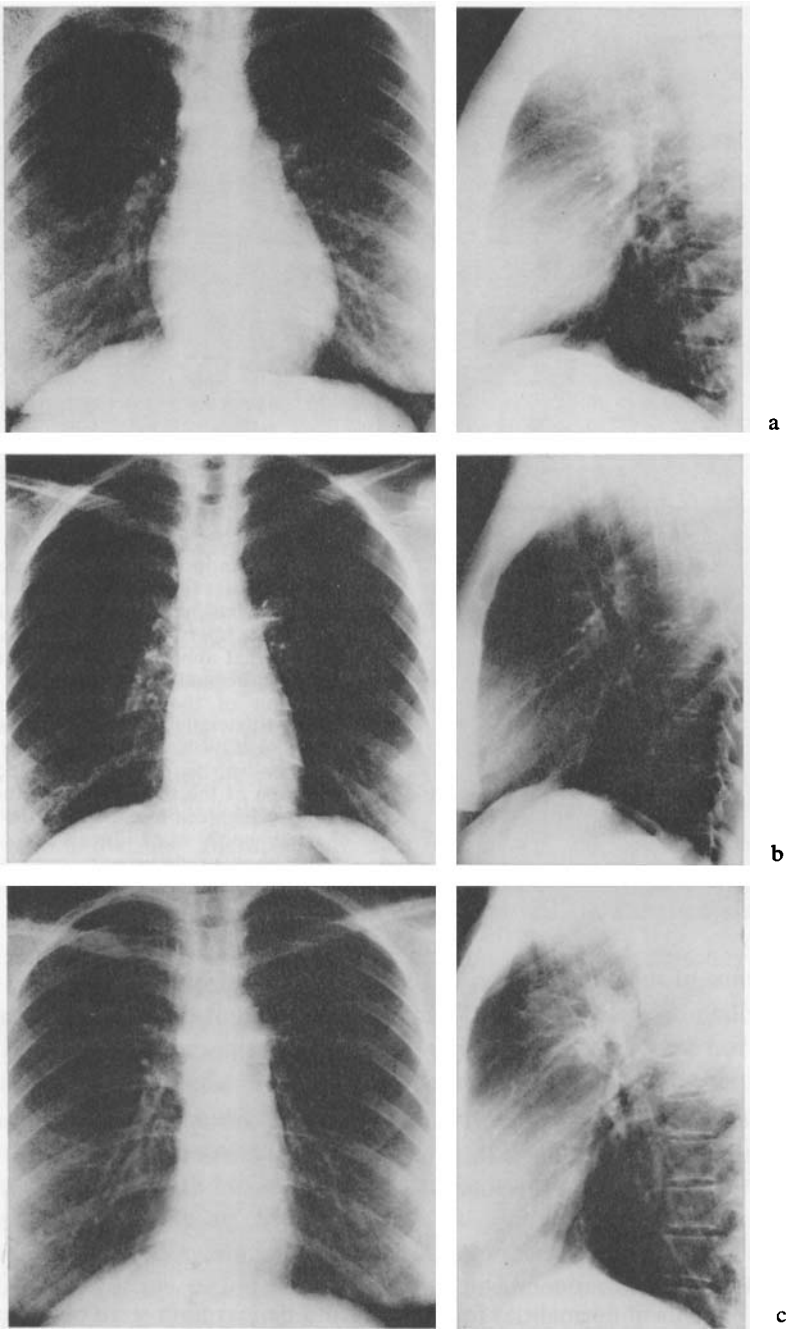

Fig. 4. (For legend, see opposite page.)

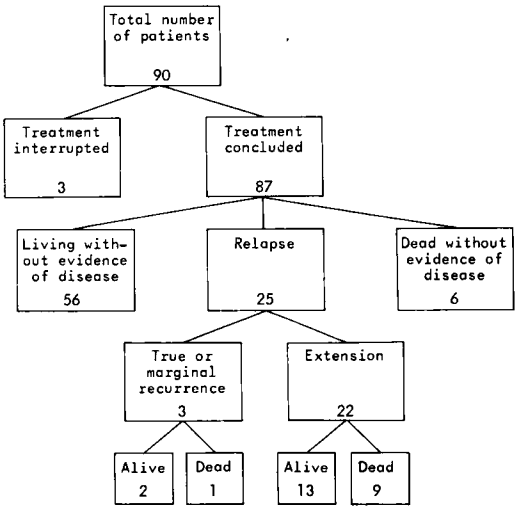

Fig. 5. Results of mantle treatment for supradiaphragmatic Hodgkin's disease, Lund 1967–1974.

was chosen as the representative one. For the patients with only one field irradiated per fraction the 'effective dose' per fraction was calculated according to KIRK et coll. (1971) from the formula:

$$d = \left(\frac{d_a^{1/m} + d_b^{1/m}}{2}\right)^m$$

where d = effective dose per fraction, d_a and d_b = absorbed dose from fields Nos 1 and 2, respectively, and m = 0.65. The gap correction was calculated according to WINSTON et coll.

At follow-up the patients had been asked for symptoms suggestive of radiation myelitis or Lhermitte's sign. The maximum absorbed dose in the whole spinal cord was recorded as the representative absorbed dose for the cord. In the present material no shield for the spinal cord had been used.

Results

The treatment was concluded in 87 of the 90 patients (Fig. 5). Fifty-six are alive without evidence of disease, 25 have relapsed, and 6 have died without known extension of disease. Data on the final course of these 6 patients are scarce, and it cannot be

Fig. 4. Changes in the cardiac outline after mantle treatment. a) Before beginning of treatment. The heart is of normal size and shape. Nothing abnormal in the mediastinum or in the lung parenchyma. b) Three months after beginning of treatment. The shape of the heart has changed and the cardiac volume has diminished. No radiation pneumonitis. c) Forty-two months after beginning of treatment. The shape of the heart has changed further and the cardiac volume has also been reduced. The changes are attributable mainly to a pericardial fibrosis, but the slight paramediastinal fibrosis with slight elevation of the hilar regions may also have contributed by stretching the pericardial sack in the cranio-caudal direction. The patient stayed cardially symptom-free.

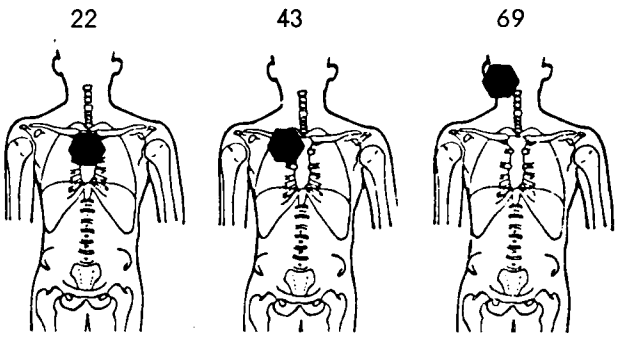

Fig. 6. Sites of true or marginal recurrences in 3 out of 87 patients after mantle treatment for Hodgkin's disease.

decided if death was due to progressive disease or to other causes. Of the 25 patients with relapse, 3 recurred locally and 22 had extensions. Fifteen of the 25 are still alive.

No local recurrence. Fifty-four patients treated with split-course treatment stayed symptom-free after the initial treatment (Table 1). The absorbed dose in the target for these patients ranged between (mean values) 43.2 Gy (4 320 rad) maximum target dose, and 37.65 Gy (3 765 rad) minimum target dose, the mean absorbed minimum dose in demonstrable tumour being 40.30 Gy (4 030 rad). The irradiations had been given in mean 27 fractions in mean 71 days. The follow-up for these 54 patients ranged from 9 to 87 months with a mean of (38 ± 20) months.

Local recurrence. A true or marginal recurrence was observed in 3 of 87 patients (3 per cent, Fig. 6); in 2 patients in the superior mediastinum (Nos 22 and 43) 5 months after mantle treatment. The absorbed dose in these two sites had been 38.5 and 40 Gy, respectively. There is no other explanation for the relapse in one of these patients (absorbed dose = 38.50 Gy) than a true recurrence, but the local recurrence in patient No. 43 may well have been a marginal recurrence, and the corresponding absorbed dose may then have been smaller than 40 Gy. The recurrence occurred in the region of the medial part of the clavicle. The recurrence in patient No. 69 may

Table 1

Absorbed dose in 54 patients being alive and without evidence of disease after split-course mantle treatment for Hodgkin's disease

	Maximum target absorbed dose (Gy)	Minimum absorbed dose in demonstrated tumour (Gy)	Minimum target absorbed dose (Gy)	Number of fractions	Number of days	Follow-up (months)
Range	39–48	32–44.5	29.5–42	20–44	51–93	9–87
Mean	43.20	40.30	37.65	27	71	38
SD	1.95	2.15	2.45	4	9	20

Table 2

Radiation pneumonitis or fibrosis in 80 patients treated with split-course mantle treatment for Hodgkin's disease and followed up for at least 6 months

	Number of patients	Age (range, median, mean, and SD)	Number of patients with mediastinal lymphadenopathy	Treatment data for the hilar regions (range, median, mean, and SD)					
				Absorbed dose (Gy)	Number of fractions	Number of days	CRE value of first series	CRE value of full treatment *	CRE value of full treatment **
Neither symptoms nor signs	17	7–54	4	37–46	20–44	54–93	710–1 367	1 148–1 438	1 025–1 217
		26		41.5	27	72	973	1 211	1 085
		27		42	28	72	989	1 221	1 102
		11		2.35	5	11	142	71	62
No symptoms, slight radiologic abnormalities	22	7–67	6	39–45	23–36	56–96	800–1 139	1 110–1 389	982–1 289
		27		41	26	71	988	1 206	1 108
		33		41.5	27	70	994	1 231	1 120
		17		1.60	3	9	108	74	88
Moderate symptoms or moderate radiologic abnormalities	14	6–58	6	37–46.5	23–40	53–97	684–1 181	1 043–1 342	957–1 204
		30		41.25	27	76	1 010	1 232	1 105
		32		41.45	27	73	992	1 211	1 093
		16		2.3	4	11	121	83	79
Marked symptoms or extensive radiologic abnormalities	27	16–71	15	38–49	21–31	51–80	812–1 177	1 164–1 470	1 059–1 360
		35		41.5	27	70	1 027	1 241	1 139
		37		42.45	27	68	1 031	1 257	1 143
		17		2.5	3	7	77	62	66

* = Gap calculated according to WINSTON et coll. (1969).
** = Gap calculated according to KIRK et coll. (1975).

well be labelled a marginal one. It occurred just below the external auditory canal. Analysis in retrospect of the repeated measurements of absorbed dose in the external auditory canal showed that in the first series abnormally low values had been recorded, whereas the upper margin of the field seemed to have been more properly adjusted in the second series.

Of patients with a local recurrence 2 (Nos 22 and 43) are still alive. Patient No. 69 died from generalized disease, he also developed acute myeloid leukemia.

Radiation pneumonitis or fibrosis. Eighty patients treated with split-course radiation therapy and followed for at least 6 months were evaluated (Table 2). Seventeen

Table 3

Radiation reactions in the heart and pericardium in 80 patients treated with split-course mantle treatment for Hodgkin's disease and followed up for at least 6 months

	Number of patients	Age (range, mean, and SD)	Treatment data for the central part of the heart (range, mean, and SD)			
			Absorbed dose (Gy)	Number of fractions	Number of days	CRE value
Neither symptoms nor signs	72	6–69	35–46	20–44	51–97	998–1 320
		31	40.6	27	71	1 196
		15	2.07	4	10	71
Symptoms or signs	8	20–71	39–43	22–30	57–72	1 026–1 277
		45	40.1	26	67	1 200
		20	3.02	2	5	84

patients had neither symptoms nor signs of pulmonary radiation reactions, 22 had no symptoms but slight abnormalities on chest films, 14 had moderate symptoms or moderate abnormalities on chest films, and 27 had severe symptoms or extensive abnormalities on chest films. The four groups of patients appear in Table 2, distributed on age, frequency of mediastinal involvement, absorbed dose (in Gy) in the hilar regions, number of fractions and days, and CRE value of absorbed dose in the hilar regions in the first series and calculated with gap correction both according to WINSTON et coll. and KIRK et coll. (1975), respectively, for the whole treatment. No evident differences exist, but some tendencies may be noted. Pulmonary radiation reactions seemed to increase with age of the patient and frequency of mediastinal lymphadenopathy, and the most severe reactions occurred at dose levels slightly higher than in patients without reaction. The presence of hilar lymphadenopathy, (totally 13 patients) cannot explain the occurrence of pulmonary radiation reactions. No difference in frequency of pulmonary radiation reactions was found between patients with only one field irradiated per fraction and those with 2 fields irradiated per fraction.

Radiation reactions of the heart and pericardium. Symptoms or signs of radiation carditis or radiation pericarditis were observed in 8 out of 80 evaluated patients (Table 3). The patients with demonstrable reactions were older, but no difference could be found as regards absorbed dose given or fractionation between patients with and patients without radiation carditis or radiation pericarditis. Of the 8 patients with radiation heart reaction, 2 had one field irradiated per fraction and 6 had 2 fields irradiated per fraction.

It may be mentioned that reactions were as a rule slight and did in no instance necessitate pericardial tapping or pericardiectomy.

Table 4

Radiation reactions of the spinal cord in 80 patients treated with split-course mantle treatment for Hodgkin's disease and followed up for at least 6 months

	Number of patients	Age (range, mean, and SD)	Treatment data for the spinal cord (range, mean, and SD)		
			Absorbed dose (Gy)	Number of fractions	Number of days
Neither symptoms nor signs	73	6–71 33 17	35–48 42 1.96	20–44 27 4	51–97 71 10
Lhermitte's sign	7	18–50 30 10	40.5–44 42.50 1.08	24–31 26 3	60–78 68 8

Radiation myelitis. Seventy-three of 80 patients had no symptoms or signs of radiation myelitis (Table 4), 7 had Lhermitte's sign, but no patient had any serious reaction from the cord. The absorbed dose in the cord had been of the order of 42 Gy in 27 fractions in 70 days, and no dose difference existed between patients with and patients without Lhermitte's sign. Age did not seem to be of importance. All patients with Lhermitte's sign had one field irradiated per fraction. Six have not received chemotherapy whereas in one patient chemotherapy with MOPP was started 6 months after the beginning of mantle treatment at the same time as Lhermitte's sign appeared.

Other tumours. It may be mentioned that out of the 90 patients, 6 have had other tumours before or after the mantle treatment. Three patients had been treated for a tumour before mantle treatment (one for intrathoracic fibroxanthoma, one for carcinoma of the breast, and one for malignant melanoma), whereas 3 have been treated for other tumours after mantle treatment (two for skin basaliomas and one for acute myeloid leukemia, the latter patient had received both total nodal irradiation and chemotherapy).

Discussion

Local recurrence. It is generally recognized that 40 Gy (4 000 rad) is an absorbed dose that gives local control in Hodgkin's disease in a reasonably high frequency (KAPLAN 1966). It has been shown (LANDBERG & FORSLO, JOHNSON, LANDBERG et coll. 1973), that the total time is not very critical, and the treatment may well be extended over a relatively long period of time, a fact that was also stressed by KAPLAN. He considered 4 000 rad given with 1 000 rad per week to give local control in 95 per cent of lesions. The remaining 5 per cent that failed to be controlled may be regarded

as extremes in the biologic variation in radiation sensitivity of Hodgkin's disease. It may also be that some of the local recurrences labeled as true recurrences in fact are marginal ones, since the frequency of uncontrolled lesions seems to increase rapidly with decreasing dose (KAPLAN 1966), and it is well known that often radiation therapy of such a complex nature as the mantle treatment may be prone to poor reproducibility in treatment set up. MARKS et coll. (1974) have for example reported on localization error in the irradiation of Hodgkin's disease and the non-Hodgkin's lymphomas. They found in 99 patients treated with the mantle technique 10 local recurrences (6 in the axilla, 2 in the neck, and 2 in the mediastinum) and could often explain by means of serial slow films these recurrences on the basis of underdosage.

The literature contains only few reports on the frequency of recurrences after mantle treatment with an adequate notation of absorbed dose in Hodgkin's disease.

MARYUAMA & KAHN (1971) found 12 patients of 36 to have local recurrences after 3 500 rad in 3 weeks. Eight recurrences occurred in the hilar regions, 2 in the axillae, 2 in the supraclavicular region, 4 in the submaxillary or preauricular region, and one recurrence was observed at the level of the suprasternal notch between two hemimantle ports. The authors discussed possible ways to diminish the high frequency of local recurrence by means of different techniques.

RUBIN et coll. (1969) reported 11 local recurrences in 65 patients after mantle treatment, and 12 patients with local recurrence out of 83 treated (RUBIN et coll. 1974). Nine of these recurrences were localized to one nodal region and the other 3 presented at more than one nodal site. There were 4 recurrences in the hilar nodes, 7 recurrences in the neck nodes, 4 in the axillary nodes and 2 in the epitrochlear nodes. Approximately half of the local recurrences were considered to be marginal ones. MARKS et coll. (1974) reported 8 local recurrences in 68 patients.

FAW et coll. (1971) found only one local recurrence in 80 patients, and FAZEKAS et coll. reported 3 local recurrences in 83 patients, the absorbed dose in the two series having been 4 000 rad and 3 600 to 4 400 rad, respectively.

Most of the local recurrences reported have occurred in the hilar and the submaxillary regions. Attempts to diminish the frequency, severeness, and seriousness of radiation pneumonitis may well counteract attempts to deliver a tumoricidal absorbed dose in the hilar regions. Recurrences in the submaxillary region are probably often due to faulty immobilization of the patient or simply to the fact that the field border was placed too caudally in order to avoid dryness of the mouth. A rather interesting site for recurrence is medially in the infraclavicular fossa. This seems not to have attracted much attention, though 2 such recurrences were reported by ROSENBERG & KAPLAN (1966) in 20 patients treated with the mantle technique. One of the patients in the present material demonstrated a recurrence in a position corresponding to the medial part of the infraclavicular fossa and upper mediastinum. The occurrence of infraclavicular chest wall tumours in Hodgkin's disease was reported in 6 of 91 patients by GOLDMAN (1952), and FUCHS (1969) has shown on lymphography that lymph nodes may fill up in a site that corresponds to the medial

part of the infraclavicular fossa rather caudally. Shielding in this region may be hazardous.

The low frequency of local recurrence in the present material (about 3 per cent) indicates that it is quite safe to use split-course treatment with an absorbed dose in the target of 40 Gy given in 27 fractions in two series over totally 10 weeks.

Retreatment of a local recurrence has usually been successful only in the hilar region, and RUBIN et coll. (1974) stated that 'the initial management decision at the time when the patient is first seen is the most critical if cure is to be achieved by irradiation'.

Lung tissue. In a previous report (LANDBERG et coll. 1971) a detailed description was given of radiation effects of the lung tissue, heart and pericardium of 12 of the patients in the present material. Lung function examinations indicated that there was only a relatively slight decrease in the spirometric values. The ECG was normal in all but one patient, who had an S:R ratio of more than 1.0; this patient also had tachycardia.

In most of the present patients no prospective lung function examinations were performed.

Radiation reactions of the lung tissue, heart and pericardium proved not to be of any serious significance, though transient symptoms of radiation pneumonitis were often relatively severe.

The frequency of radiation pneumonitis and radiation lung fibrosis has been the subject of numerous reports (COULTER et coll. 1972, LIBSHITZ et coll. 1973, HØST & VALE 1973, LOKICH et coll. 1973, EVANS et coll. 1974). Since it is rarely if ever demonstrated how much lung tissue that was included in the mantle field or whether the absorbed doses reported have been corrected for tissue heterogeneity, it is difficult to make a meaningful pooling of the dose-response relationship of the lung tissue in mantle treatment of Hodgkin's disease.

COULTER et coll. reported on lung function analyses in 89 patients after mantle treatment for Hodgkin's disease. Two patients died of pulmonary insufficiency and cor pulmonale. Other pulmonary complications were tracheooesophageal fistula, pneumothorax, and atelectasis. Forty-four per cent of the patients were asymptomatic.

LIBSCHITZ et coll. reported on 20 patients, 19 with radiation lung fibrosis, and 13 with radiation pneumonitis. The authors concluded that there is a time-dose relationship of the pulmonary parenchymal radiation reactions. Two of their patients also had radiation pericarditis.

HØST & VALE reported lung function examinations in 17 patients after mantle treatment. The vital capacity was reduced at the end of treatment with on the average 10 per cent. No influence on the pulmonary gas exchange could be demonstrated.

LOKICH et coll. found that the diffusing capacity may be reduced already before irradiation, and patients with intrathoracic Hodgkin's disease had lower pulmonary

indices which improved with tumour resolution. Total lung capacity and inspiratory capacity were maximally affected at 9 months but returned towards normal by 24 months. Similar findings were noted by EVANS et coll.

BORGNES & HATLEVOLL (1971) reported on lung complications in a series of 70 patients. One third of the patients had no radiologic lung abnormalities. Two patients died from respiratory insufficiency and cor pulmonale.

PATERSON (1963) recommended 3 000 rad in 3 weeks as an upper dose limit for any major irradiation of lung parenchyma. This dose limit corresponds to a CRE value of 1 150. If the entire lungs and the mediastinum are irradiated, the same author puts the limit at 2 500 rad, which when given in 3 weeks corresponds to a CRE value of 950.

With the mantle fields used in the present material about one third to half of all lung tissue was irradiated to an absorbed dose of about 40 Gy. The rest of the lungs received a dose of 4 to 7 Gy (400 to 700 rad) from scattered radiation and primary radiation through the lung blocks. With gap-correction according to WINSTON et coll. (1969) this is equivalent to a CRE value of 1 225, and with gap correction according to KIRK et coll. (1975) it is equivalent to a CRE value of 1 100. For the irradiated volume and the time-dose schedule usually used in the present material these figures seem to represent a borderline region between negligible and serious lung reactions and thus may represent the tolerance limit for the lung tissue in mantle treatment.

Heart and pericardium. Radiation reactions of the heart and pericardium have been reported to occur with various frequency and different grade of severity and seriousness. BYHARDT et coll. (1975) reported radiation-related pericardial effusion in 24 out of 83 patients treated with the mantle technique for Hodgkin's disease. In 4, surgical procedures proved necessary. The average midplane cardiac absorbed dose in the whole series corresponded to a Nominal Standard Dose (NSD, ELLIS 1969) value of 1 558, and the pericardial dose to a NSD value of 1 823. No obvious correlation between any value of NSD and the occurrence of cardiac or pericardial reactions could be demonstrated.

Other reports (COHN et coll. 1967, STEWART et coll. 1968, FAJARDO et coll. 1968) have indicated that there may be a rather evident dose-limit for radiation reactions of the heart and pericardium, corresponding an NSD value of 1 500–1 850, depending on the size of the irradiated tissue concerned. In the present series of patients, in whom the cardiac dose corresponded in general to a CRE value of about 1 200, radiation reactions of the heart and pericardium had no serious clinical significance. Pericardial effusion did not occur. In some of the patients the transverse cardiac diameter decreased as reported previously by PIERCE et coll. (1969).

Spinal cord. In the present material no serious symptoms of radiation myelitis were encountered. A few patients had a moderate Lhermitte's sign.

Other tissues. It may further be mentioned that since the upper border of the field had been placed rather high cranially to secure an adequate absorbed dose in the lymph nodes at the tip of the mastoid, it had not been possible to avoid irradiation of much of the salivary glands. The patients therefore have usually experienced a dry mouth, and in about 10 per cent dental decay has occurred. The symptoms of dry mouth have usually diminished over a rather protracted period of time, often lasting for up to 2 years. The patients have been checked for thyroid insufficiency, and thyroid substitution has proved necessary in some patients. Subcutaneous fibrosis in mainly the neck and supraclavicular region has occurred in some patients, but was clinically of no serious significance.

In a previous report (LANDBERG et coll. 1972) a review was given of the radiation sensitivity of tissues irradiated during mantle treatment of Hodgkin's disease. It was concluded that the irradiation may with advantage be extended over a relatively long period of time in order to minimize the risk for radiation reactions of healthy tissues. The present results confirm this opinion. With the technique used the main untoward reactions have been pulmonary radiation reactions and a dry mouth, whereas minor reactions have been encountered from the heart and pericardium or the spinal cord. In general, younger persons seemed to tolerate the treatment better than old ones.

SUMMARY

Eighty-seven patients were treated with the mantle technique for Hodgkin's disease. Usually 40 Gy in 27 fractions in two series over 71 days were given. A local recurrence was diagnosed in 3 of 87 patients. An analysis of radiation reactions of the lung tissue, heart and pericardium, and spinal cord is reported. It is recommended to give mantle treatment for Hodgkin's disease over a relatively long period of time such as in split-course in two series.

ZUSAMMENFASSUNG

Siebenundachtzig Patienten mit Hodgkin'scher Erkrankung wurden mit der Manteltechnik behandelt. Gewöhnlich wurden 40 Gy in 27 Fraktionen in zwei Folgen während 71 Tage verabfolgt. Lokale Rezidive wurden bei 3 von 87 Patienten diagnostiziert. Es wird über eine Analyse der Strahlenreaktionen des Lungengewebes, des Herzen, des Perikards und des Rückenmarkes berichtet. Es wird empfohlen, die Mantelbehandlung bei der Hodgkin'schen Erkrankung über eine relativ lange Zeitperiode wie bei der fraktionierten Behandlung in zwei Abschnitten zu geben.

RÉSUMÉ

Quatre-vingt-sept malades ont été traités par la technique en mantelet pour maladie de Hodgkin. Le plus souvent on a administré 40 Gy en 27 fractions en deux séries sur 71 jours. On a constaté une récidive locale chez 3 de ces 87 malades. Les auteurs présentent une analyse des réactions aux radiations du tissu pulmonaire, du coeur et du péricarde,

et de la moelle épinière. Ils recommandent d'administrer le traitement en mantelet pour la maladie de Hodgkin sur une période de temps relativement longue comme un split-course en deux séries.

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