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EXTERNAL SMALL-FIELD IRRADIATION OF CERVICAL CARCINOMA WITH LINEAR ACCELERATOR

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For treatment of carcinoma of the uterine cervix, combined intracavitary and supervoltage external radiation therapy has been the most common method, and excellent results have been reported (ROUSSEAU et coll. 1972, BOURNE & ROBERTS 1972). The intracavitary therapy, however, is accompanied by various problems, such as poor reproducibility in homogeneous dose distribution which may result in high incidence of injuries to the rectum and bladder, even if severe complications are encountered in only about one per cent, and exposure of the therapist to radiation.

Reports on excellent results of external irradiation alone have appeared, but they are fragmentary and the lesions have probably not always been precisely positioned within the irradiated volume (MOTT et coll. 1974, TRUMP et coll. 1954, MELLOR 1960, BACLESSE 1950).

The roentgen radiation from a linear accelerator is characterized by slight penumbra and minimal scattering. Based on these advantages, additional small-field irradiation was delivered following irradiation of the entire pelvis. A new beam-directing device was constructed which allows a narrow beam to be directed to the lesion, avoiding the bladder and the rectum. Since 1967, 125 patients have been treated with this technique and have been followed for at least one year. The results are now reported.

Methods

The method was mainly used in patients with inoperable advanced carcinoma of the uterine cervix, most of them in Stage III (Table 1). The radiation procedure employed was as follows:

Submitted for publication 25 July 1977.

Table 1

Stage distribution

Stage	No. of cases	Per cent
I b	5	4
II	28	22
III	85	68
IV	7	6
Total	125	100

1. Pelvic irradiation. The pelvis was irradiated from antero-posterior and postero-anterior opposing fields, size 15 cm × 15 cm. A mid point dose of about 60 Gy (6 000 rad) was given over 6 weeks, 5 times a week, with a 6 MV roentgen beam from a linear accelerator. The fields were hexagonal and sufficiently wide to include the common iliac lymph nodes and the cardinal ligament lymph nodes, located by lymphangiography. The dose distribution appears in Fig. 1.

2. Small field irradiation. The 6 MV beam was directed to the primary tumour, avoiding the bladder and the rectum (SAKAGUCHI et coll. 1974) with the new beam-directing device. This consists of a piece of light alloy about 2 m long, supported by a pivot in the ceiling which is movable in any direction and also can slide on the pivot (Fig. 2). One end of the rod is equipped with a device for immobilizing the uterus. The other end is connected to three linear potentiometers for the x, y, and z axes. Even the slightest change in the position of the uterus is detected as an electric signal (Fig. 3). For determining the volume to be irradiated, the bridge circuit is first balanced so that the gauges register zero at a certain position of the uterus. With the gauges at zero, the device is inserted into the cervical canal, and the position of the patient is precisely adjusted (Figs 4, 5).

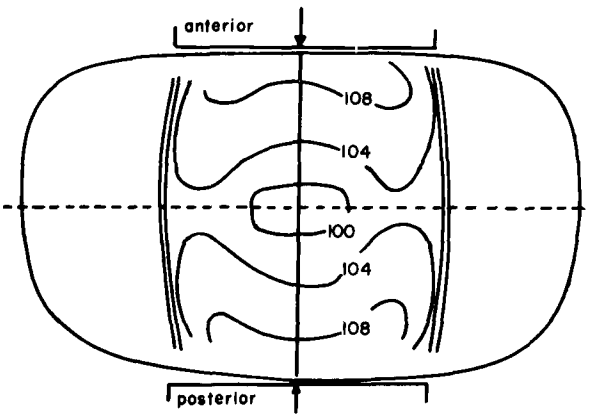

Fig. 1. Isodose distribution of pelvis irradiation. Technique: two parallel opposing fields 6 MV roentgen ray (Linac), fields 15 cm × 15 cm, TSD 100 cm.

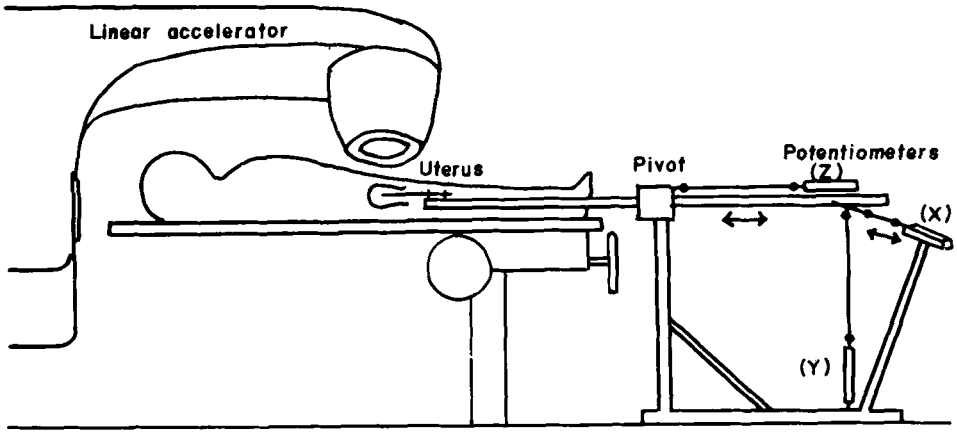

Fig. 2. The slightest deviation in the position of the uterus produces a change in the electric resistance of the potentiometer via the long rod.

A localization film exposed with the therapy beam appears in Fig. 6. After completion of the pelvis irradiation, a tumour dose of 10 to 15 Gy was delivered three times every second day up to a total dose of 30 to 45 Gy to a reduced volume with the primary tumour in the center. The field size, 50 to 70 mm × 25 to 40 mm, was adjusted to the size of the primary tumour and that of the uterus. Moving beam therapy with a lateral pendulum movement of 60° was used in all cases. The dose distribution over this small irradiated volume is illustrated in Fig. 7. By this means, the dose both to the rectum and to the bladder was reduced. The total dose in Point A and Point B used in the Manchester system (TOD et coll. 1953) was about 105 and 80 Gy, respectively.

Results

The 125 patients observed for more than 1 year after the irradiation were analysed and the results are given in Table 2 and Fig. 8.

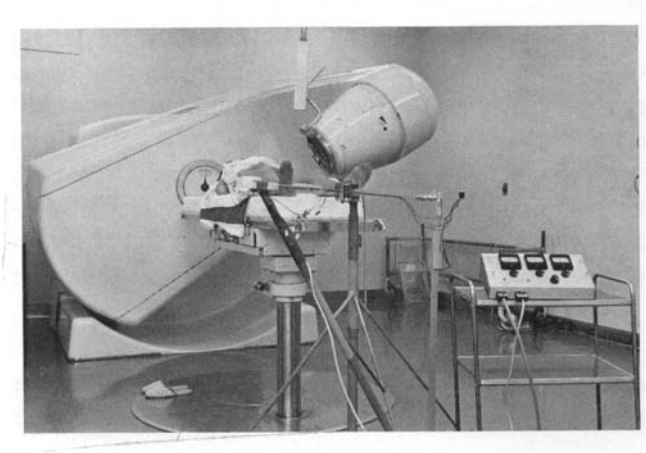

Fig. 3. The device for immobilization of the uterus is inserted into the cervical canal with the patient in the lithotomy position.

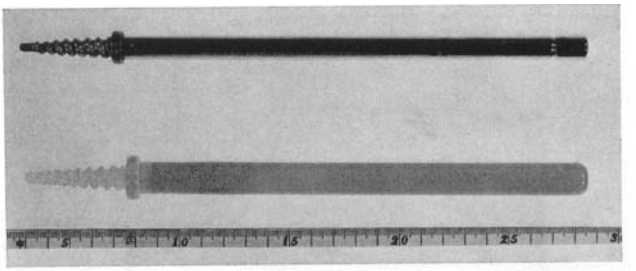

Fig. 4. The devices. A tapered screw facilitates insertion of the rod into the cervical canal.

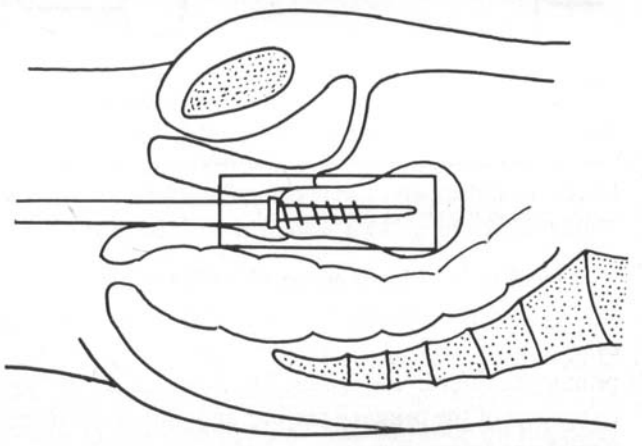

Fig. 5. The device is inserted after dilating the cervical canal with Hegar's dilator.

Five-year results were obtained in 48: 25 lived without malignancy; none survived with malignancy; 20 had died of the malignant disease, and 3 of other diseases. The five-year crude survival rate is 52 per cent. The survival rate for patients stage III and IV, the majority of the patients, was 46 per cent (Fig. 8). This result must be regarded as very gratifying in patients with such advanced disease, and the method seems especially suitable for stage III cases.

Most of the 20 patients who had died of the malignant disease were examined at autopsy as to the presence of malignant cells in the primary lesion (Table 3).

The frequency of late injuries to the patients who additionally received small-field irradiation were compared with that in 67 patients given pelvis irradiation alone. Virtually no difference between the two groups of patients was found. Ileus occurred in only one patient, who had received additional irradiation. Cystic hemorrhage occurred in one and rectal hemorrhage in 5; these complications were mild, requiring no treatment, except in 2 patients with rectal hemorrhage who required blood transfusion. Severe cystic and rectal hemorrhages occurred in 2 patients following an additional intracavitary irradiation due to recurrence several months after the primary treatment.

Discussion

The roentgen beam from a linear accelerator makes accurate irradiation possible because of its slight penumbra and minimal scattering. These characteristics are most

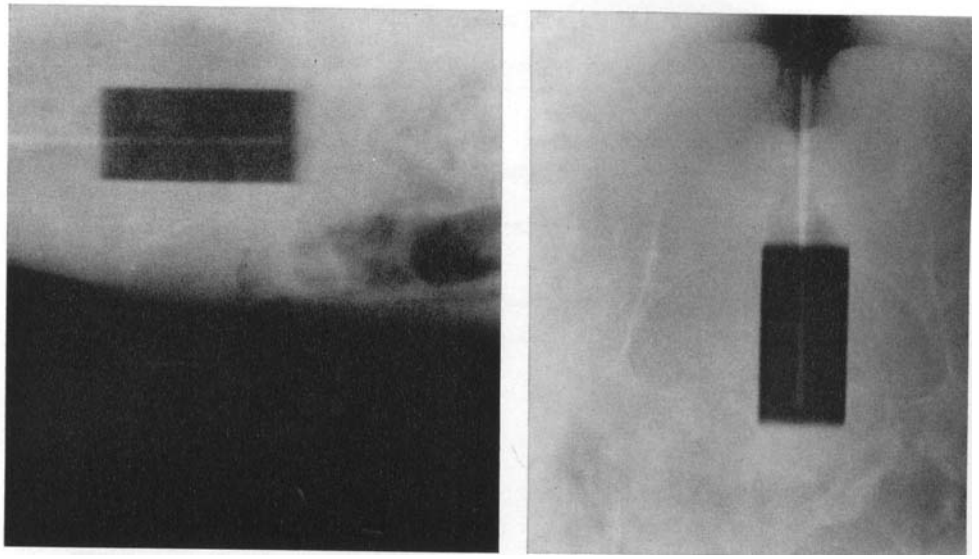

Fig. 6. Localization film. Device in place (center).

valuable if a small field is irradiated. It is impossible to position the lesion accurately in a narrow beam by skin marking. Therefore, a special beam-directing device with high accuracy was designed.

With the isodose distribution illustrated in Fig. 7, it is possible to irradiate a lesion with a sufficient dose while avoiding excessive irradiation of the bladder and the

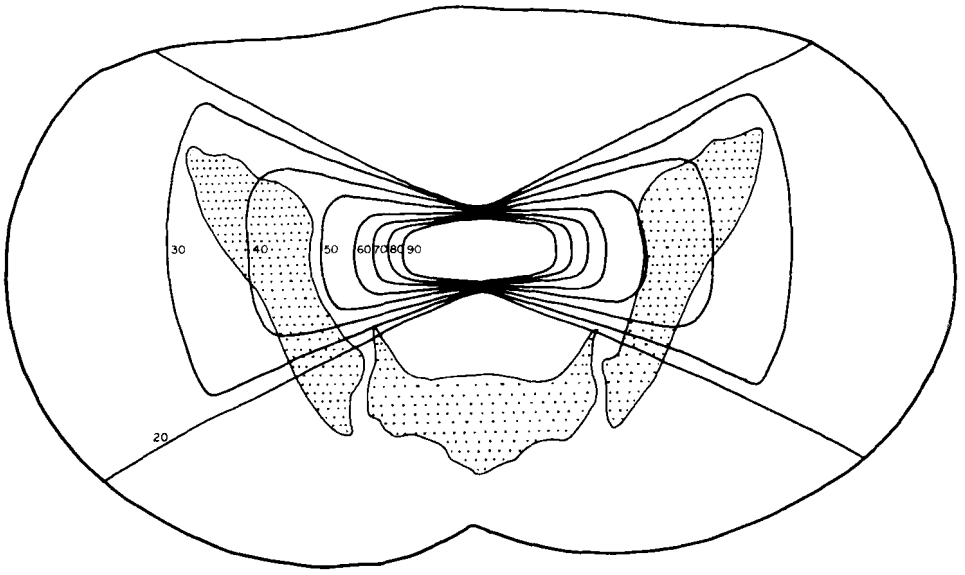

Fig. 7. Isodose distribution for a 6 MV linear accelerator, using a field size of 60 mm × 25 mm and a 60° lateral pendulum.

Table 2

Stage distribution and survival rate at different intervals after treatment

Year after treatment	Stage	No. treated	Alive without carcinoma	Alive with carcinoma	Dead of carcinoma	Dead of intercurrent disease	Survival rate (%)
1	I b	5	5	0	0	0	100
	II	28	27	0	0	1	96
	III	85	73	4	7	1	91
	IV	7	6	1	0	0	100
	Total	125	111	5	7	2	93
2	I b	5	5	0	0	0	100
	II	25	22	0	2	1	88
	III	71	43	3	24	1	65
	IV	5	1	0	4	0	20
	Total	106	71	3	30	2	67
3	I b	4	4	0	0	0	100
	II	17	13	0	3	1	76
	III	57	29	2	23	3	54
	IV	4	1	0	3	0	25
	Total	82	47	2	29	4	60
4	I b	3	3	0	0	0	100
	II	13	9	0	3	1	69
	III	46	22	0	22	2	48
	IV	4	1	0	3	0	25
	Total	66	35	0	28	3	53
5	I b	2	2	0	0	0	100
	II	9	6	0	2	1	67
	III	34	16	0	16	2	47
	IV	3	1	0	2	0	33
	Total	48	25	0	20	3	52

rectum. The method also makes it possible to vary the irradiated volume from one patient to another, with a high degree of reproducibility.

Even in patients with an advanced malignant disease invading the pelvic wall and thus with no mobility of the uterine cervix, pelvis irradiation with 60 Gy reduced the tumour to such an extent that the positioning device for the small-field irradiation could be easily inserted. In only 10 per cent of the patients could the device not be inserted. Recently, a polyethylene tube was inserted into the uterine cervix 2 to 3 days in advance, which facilitated insertion of the device on the day of irradiation.

MELLOR has raised the question whether intracavitary irradiation is still necessary in the treatment of carcinoma of the uterine cervix, or whether it instead may be replaced by external supervoltage irradiation. He stated that the theoretical advantages

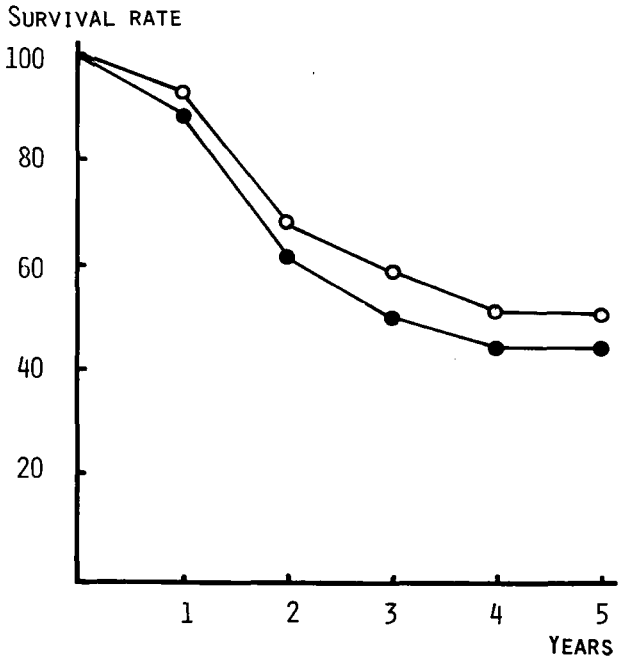

Fig. 8. Survival rates (per cent) for stages [illegible] (-●—●-) and total cases (○—○-) of cervical carcinoma

postulated for such a treatment are that the primary lesion and its areas of direct and lymphatic spread in the pelvis could be irradiated simultaneously and homogeneously with adequate doses without local overdosage; moreover, no anesthesia would be needed and there would be little irradiation hazard for the operator and the staff.

As a result of small-field irradiation with a total dose of 30 Gy [illegible] pelvis irradiation with 40 Gy, KOECK et coll. (1962, 1966) achieved a three-year survival rate of 69 per cent of the total number of cases, a higher survival rate than those reported by other authors. CASTRO et coll. (1970) reported that a basic tumour dose of 50 Gy in 5 weeks was insufficient to control cervical carcinoma and that patients with limited tumours could be treated effectively with this basic dose to the pelvis, supplemented with 20 Gy through reduced fields directed to the cervix.

Table 3

Presence of carcinoma in the primary lesion at autopsy

	Stage			Total
	II	III	IV	
Carcinoma	1	4	1	5
No carcinoma	0	10	0	10
Unknown	0	3	2	5
Total	1	17	3	20

The present results were obtained without major radiation injury. In the series diarrhea during irradiation was markedly reduced by decreasing the dose from 2 to 1.5 Gy/day. Following this reduction of the daily dose, diarrhea virtually never necessitated withdrawal of the irradiation. Virtually no irradiation injuries could be attributed to the additional small field irradiation, and late injuries of the rectum, of the bladder, or ileus were seldom encountered.

MELLOR also stated that supervoltage radiation therapy alone was accompanied by low incidences of injuries to the bladder or the rectum, and pelvic fibrosis.

Although many of the patients were elderly and had advanced carcinoma, favourable results were achieved, and the frequency of late injuries was low. Probably the technique of external supervoltage irradiation of cervical carcinoma may be further developed, improving results. Before a definite evaluation is possible, particularly as regards the incidences of late radiation sequelae, more long term observations are needed.

SUMMARY

Since 1966, 125 patients with carcinoma of the uterine cervix were treated with a 6 MV roentgen beam from a linear accelerator. The pelvis was irradiated with 60 Gy followed by 30 to 45 Gy to a small volume using a lateral pendulum. The small-field irradiation was performed using a new beam-directing device consisting of a rod with a central pivot. Favourable results were achieved, despite the fact that most of the patients had advanced carcinoma.

ZUSAMMENFASSUNG

Seit 1966 wurden 125 Patienten mit einem Karzinom der Cervix uteri mit 6 MV Röntgenstrahlen von einem Linear-Accelerator behandelt. Das Becken wurde mit 60 Gy bestrahlt und im Anschluss daran wurden 30 bis 40 Gy zu einem kleinen Volumen mit einer lateralen Pendulum-Bewegung gegeben. Die Klein-Feld-Bestrahlung wurde unter Verwendung einer neuen Strahlengangrichtenden Anordnung, das aus einem Stab mit einer zentralen Drehungsachse besteht, vorgenommen. Günstige Ergebnisse wurden erzielt, obwohl die meisten Patienten fortgeschrittene Karzinome hatten.

RÉSUMÉ

Depuis 1966, cent vingt cinq malades atteintes de cancer du col de l'utérus ont été traitées par un rayonnnement Roentgen de 6 MV, émis par un accélérateur linéaire. Le bassin a été irradié par 60 Gy suivis par 30 à 45 Gy à un petit volume, en utilisant un mouvement pendulaire latéral. L'irradiation du petit champ a été faite au moyen d'un nouveau dispositif de direction du faisceau consistant en une tige avec un pivot central. Les auteurs ont obtenu des résultats favorables bien que la plupart des malades aient un cancer avancé.

REFERENCES

BACLESSE F.: Roentgen therapy alone in the treatment of advanced cervicouterine cancer, including extensive postoperative recurrences. Amer. J. Roentgenol. 63 (1950), 252.

BOURNE R. G. and ROBERTS S. J.: Radiation treatment of invasive cancer of the cervix in Queensland. Aust. N.Z. J. Obstet. Gynaec. 12 (1972), 131.

CASTRO J. R., ISSA, P. and FLETCHER G. H.: Carcinoma of the cervix treated by external irradiation alone. Radiology 95 (1970), 163.

KOECK G. P., JACOBSON L. E. and HILLSINGER W. R.: Cobalt-60 teletherapy of cancer of the cervix by a rotation technic. Radiology 79 (1962), 190.

— — — Results of cobalt 60 rotation therapy in carcinoma of the cervix. Amer. J. Roentgenol. 96 (1966), 81.

MELLOR H. M.: carcinoma of the cervix: treatment by supervoltage irradiation only. A preliminary report. Brit. J. Radiol. 33 (1960), 284.

MOTT T. J., MOULD R. F. and NEWTON K. A.: Experience in the treatment of carcinoma of the cervix using a rotational technique. Brit. J. Cancer 29 (1974), 66.

ROUSSEAU J., FENTON, J., DEBERTRAND PH. and MATHIEU G.: Carcinoma of the cervix. A 7-year study on 1 212 cases treated at Fondation Curie, Paris. Radiology 103 (1972), 413.

SAKAGUCHI M., FUJIWARA T. and TANAKA Y.: Small-field irradiation in carcinoma of the cervix, using a linear accelerator and a new beam-directing device. Radiology 112 (1974), 193.

TOD M. C. and MEREDITH W. J.: Treatment of cancer of the cervix uteri. A revised 'Manchester method'. Brit. J. Radiol. 26 (1953), 252.

TRUMP J. G., GRANKE R. C., WRIGHT K. A., EVANS W. W., HARE H. F., EWERT E. E. and CONLON W. E.: Treatment of tumors of pelvic cavity with supervoltage radiation. Amer. J. Roentgenol. 72 (1954), 284.