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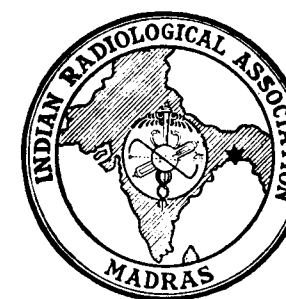
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VOLUME 3

AUGUST 1949

No 3.

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THE INDIAN JOURNAL OF RADIOLOGY

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August, 1949

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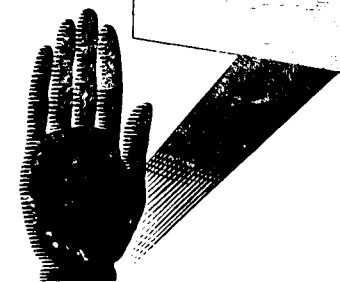
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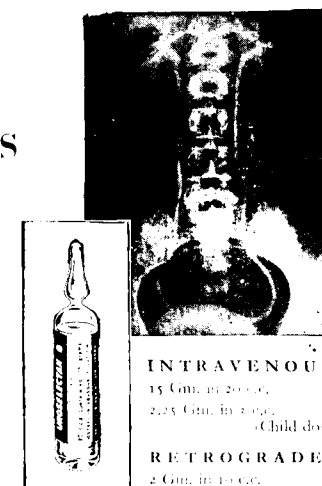
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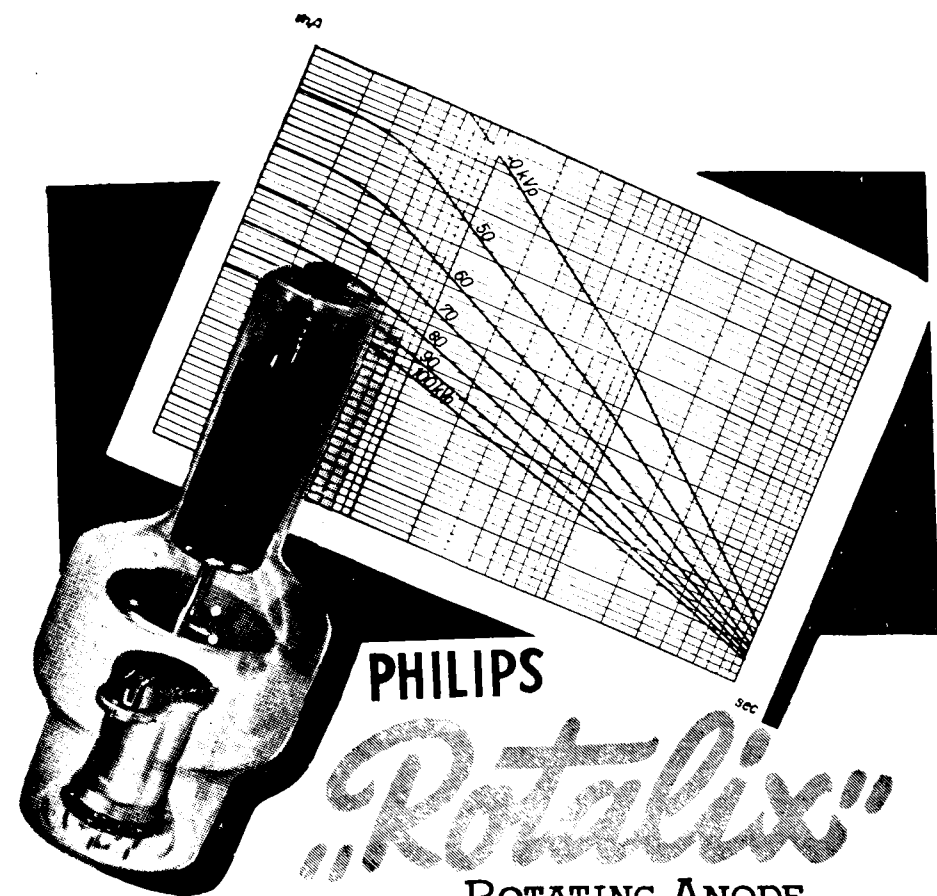
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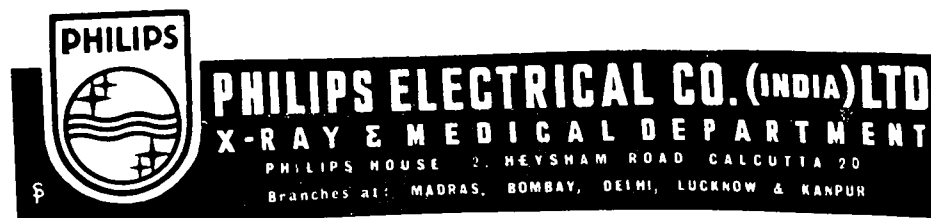


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The Indian Journal of Radiology

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AUGUST, 1949

No. 3.

Ewing's Tumour

A REPORT ON 27 CASES

VYANKAT G. VOHRA,

(DEPARTMENT OF RADIOLOGY, TATA MEMORIAL HOSPITAL, BOMBAY.)

EWING in 1921, first described a distinct malignant tumour occurring in the soft tissues of the skeleton and called it "endothelial myeloma." It is described in the literature as a relatively rare disease. Our records show a total of 27 cases of Ewing's tumour between the year 1941 to 1947. Of the total number of 9985 patients examined at the Tata Memorial Hospital between the period 1941 to April, 1945, 9640 were found to suffer from malignant disease of various tissues of the body. Sixty-five of these were primary malignant bone tumours; sixteen of these primary bone malignancies, were Ewing's Sarcoma. Thus of the total number of 27 Ewing's tumours

seen to date 16 were upto 1945 and 11 were seen between 1945 to end of 1947. The following table shows the incidence of age, sex, duration of symptoms and site of origin of the 27 cases collected from our files. A positive microscopic diagnosis of Ewing's tumour was obtained in 25 cases after aspiration or formal biopsy and in 2 cases after autopsy; in both autopsied cases the pathologist reported the adrenals as normal. (*Vide Table 1, page 108*).

The disease is more common in men than in women. Twenty of 27 patients were males and 7 females. Although no age seems to be exempt, the disease usually affects persons

* Paper read before the 3rd Indian Radiological Conference, Calcutta.

in the second and third decades of life. Nineteen of our patients were within this age period. The youngest was 4 years of age, the eldest being 50. The duration of disease in all our cases, except two, was within 1 year. In one patient the duration of symptoms was three and a half years.

Site of Origin

The bones of the pelvic girdle and the lower extremities are the most common sites of disease. It may, however, affect any part of the skeleton, including the vertebrae, ribs, skull and even the small bones of the hands and feet. In 19 of our cases the disease was located

TABLE I

Case No.	Age	Sex	Duration on admission	Bone involved	Trauma
598	20	Male	9 months	Left femur (amputated)	Lower end
2316	23	Female	1 year	Left pubic bone	
2498	44	Male	9 months	Right ribs	
3561	50	Male	6 "	Right femur—mid-shaft	
4066	30	Male	5 "	Left femur—(neck)	
4155	6	Female	8 "	Right tibia and lower end femur.	
5004	30	Male	4 "	Left femur upper	
5452	12	Female	4 "	Right femur	
5616	34	Male	4 "	Right upper humerus—Epi-physis involved.	
5814	16	Male	3 years re-moved re-currence 3 months	Ribs	
7124	13	Male	4 months	Right acetabulum	Lower third
7361	24	Male	2 years	Right pubic bone	
7470	10	Male	4 months	Right mastoid	
8356	4	Male	5 weeks	Frontals	
8665	15	Male	7 months	Left ilium	
9017	6	Female	2 "	Right femur	
9615	30	Male	1 year	Left ilium	
10519	10	Female	6 weeks	Right fibula	
12302	11	Female	3 months	Left upper tibia—(metaphysis).	
13134	28	Male	9 "	Right Ilium	
13161	20	Male	10 "	Right humerus—epiphysis: glenoid and joint	
13250	23	Male	3 "	Right ilium	
G 496	16	Male	8 "	Left fibula	
G 2293	26	Female	6 "	Right 3rd rib	
G 2830	25	Male	1 year	Left upper end fibula	
G 3156	8	Female	2½ months	Left femur	
G 3354	16	Male	4 "	Frontal bone	

TABLE I-a

Age in years	No. of cases	Years
1-10	6	(4, 6, 6, 8, 10, 10).
11-20	9	(11, 12, 13, 13, 15, 16, 16, 20).
21-30	9	(23, 23, 24, 25, 26, 28, 30, 30).
31-40	1	(35).
41-50	2	(41, 50).

TABLE I-b

Duration of Symptoms

Period in months	No. of Cases
1-3	6
3-6	9
7-9	6
10-12	4
Above 12	2

in the pelvic girdle and the lower extremities. None of our series had involvement of the vertebrae or the small bones of the extremities. When occurring in long bones the disease, was believed to affect only the shafts. In our material the ends of long bones were more often involved. Thus we had three cases with involvement of ends of the femora, two in the upper end of the humerus, two in the upper end of tibia, one in lower end of fibula. In one patient, lower end of a femur with corresponding upper end of tibia were involved. The disease is

believed to start in the Haversian canals, subperiostally, or in the medulla. Extent of medullary involvement is usually greater than shown in a skiagram. This is so because the disease is seen in the radiogram only when it affects the medullary side of the cortex and produces osteolysis or sclerosis. As the disease advances, it destroys the cortex, spreads underneath the periosteum, destroys it and produces variable amount of invasion of soft tissue. Thus a large soft tissue swelling—as distinct from an osseous swelling—is a sign of advanced disease with cortical destruction. Potozky and Fried have reported a group of cases of Ewing's tumour with a large soft tissue mass as a presenting sign in which the radiogram gave no indication of the osseous origin. Autopsy examination however showed involvement of surface layers of bone. In this connection it is worth mentioning, that the soft tissues of the extremities are stated, to be often the site of a round cell tumour, histologically resembling Ewing's tumour and showing a similar radio-sensitivity.

Clinical Data

Clinically it usually presents the well-known inflammatory complex of fever, pain, swelling and leucocytosis. A history of fever is not present in all. Pain is a constant feature. It varies from moderate

to very severe, is often intermittent in character, and is more marked at night. Pain in other parts of the skeleton is the earliest indication of metastasis. With this early metastasis the radiogram is usually negative. Six of our patients gave a definite history of trauma. The rest had either no trauma or no definite awareness of it. Trauma seems to have no direct causal relation to bone tumours, for were it so the incidence of bone tumours should be much higher than it actually is, and yet it is difficult to escape the impression that trauma in some cases is an exciting cause. Enlargement of nearest draining lymph nodes is often present. Five of our patients had enlarged nodes, three in the groin, one in the neck and one in the popliteal fossa. Two of our patients (Nos. 1230 and 6545) had rounded masses in the upper abdomen. In one of these the bone lesion was in upper tibia, in the other in mid-femoral region. The abdominal masses were noticed two and five months respectively after the bone lesion was seen. In both these cases, possibility of a primary (clinical) neuroblastoma cannot be excluded. The disease progresses fairly rapidly metastasising rapidly to the nearest lymph nodes, the lungs and the distant bones and leading to a fatal termination within a few months to a couple of years.

Laboratory Findings

All of our patients, except one, showed leucocytosis, the W.B.C. count varying between 8 to 20 thousands. One patient had a W.B.C. count of 4 thousands. Seven patients had moderate to severe anaemia, the R.B.C. count being below 4 millions on admission. In the rest the count was about 4.5 millions. The serum calcium varied round 10 mg. %; the phosphorus values were within normal limits. Alkaline phosphatase varied between 1.5 to 5.5 B. Units. Acid phosphatase values were normal. Kahn's test was negative in 18 patients; in the rest the test was not done.

In osteogenic sarcoma the values for serum alkaline phosphatase were between 10 to 16 B. Units. The higher values of alkaline phosphatase in osteogenic sarcoma could be utilised as additional diagnostic help for differentiation from Ewing's sarcoma.

Roentgen Manifestations

Roentgen examination of bone tumours is now established as an indispensable diagnostic procedure. For some time, fixed roentgen criteria were ascribed to different varieties of tumours. For instance the "Sun-ray" appearance was considered characteristic of osteogenic sarcoma, the "Onion peel" appearance in Ewing's tumour, "Soap bubble" appearance was considered very typical of "Giant cell

tumours." A definite diagnosis of the cellular nature of the tumour was given by radiologist. Now the impression is gaining ground that these so-called characteristic appearances are, after all not so "characteristic." Roentgen examination can give definite evidence of malignancy in advanced cases. In early cases even this is not always possible. Malignant bone lesion is a progressive disease. Roentgen ray appearances will therefore vary with the activity of the neoplasm and the response of the stroma. As Macdonald and Budd say "the appearance of a bone tumour at a given time depends upon the balance between the neoplastic activity (osteolysis) and the degree of cortical and medullary reaction (sclerosis) as well as the absence and extent of ossification and calcification." The characteristic appearances in a radiogram are thus a reflection of the activity of the growth. These appearances would not always indicate the tumour type. To attempt to give a definite diagnosis of the cellular make up from the roentgenogram alone is to fail to recognise the limitations of the method. This can only bring the roentgen

diagnostic method to disrepute. The following table gives an analysis of the main roentgen findings in Ewing's tumour. We have followed the method of presentation of Swensen with slight modification.

Osteolytic destruction of the involved bone is the most frequent radiological finding. Twenty-one of 24 of our cases whose radiograms were available showed marked

TABLE II
Analysis of Roentgen Appearances

Case No.	Cortical condensation	Osteolysis	"Onion peel" reaction	Other periosteal reaction
598		X-ray not available		
2316	0	+	0	0
2498	0	+	0	+
3561	0	+	0	+
4066	0	+	0	+
4155	0	+	0	+
5004	+	+	+	+
5452	+	+	+	+
5616	0	+	0	Slight
5814	0	+	0	0
7124	0	+	0	0
7361	0	+	0	0
7470	0	+	0	0
8356	0	+	0	+
8665	+	Scanty		0
9017	0	+	+	+
9615	0	+	0	0
10519	0	+	0	0
12302	+	+	+	0
13134	0	+	0	0
13161	+	+	0	Scanty
13250	0	+	0	0
G 496	0	+	+	0
G 2293	0	+	0	0
G 2830				
G 3156	0	+	0	+
G 3354	0	+	0	+

osteolysis; in the remaining 3 cases there was scanty osteolysis. Five of the patients showed variable associated cortical condensation. Osteolytic changes take on various forms. In flat bones this may appear as a complete homogenous lysis or as stippled rarefaction. In long bones the osteolytic changes are seen in various stages and locations. This may manifest as sub-cortical erosion, or as destruction of the medullary side of the cortex and widening of the medulla. When affecting the Haversian canals various degrees of mottled rarefaction of the cortex is seen. In other cases the affected shaft shows a "honey-comb" appearance. Occasionally the whole of the involved bone is completely destroyed with thin strips of bone lying in the tumour mass, as faint remnants of the original cortex.

Condensation of bone, when present may occur intracortically or subperiosteally. Intracortical condensation is due to diffuse deposition of bone among the trabecular structure. This produces increased density of the cortex and sometimes narrowing of the medullary canal. Unlike osteogenic sarcoma, there is no bone formation by the tumour cells. Only reactive bone is produced.

A variety of patterns is presented by sub-periosteal new bone formation. The well-known "Onion peel"

appearance is only occasionally seen in Ewing's tumour. On the other hand it is sometimes seen in chronic pyogenic or syphilitic osteomyelitis. Its presence therefore does not confirm nor its absence exclude the diagnosis of Ewing's tumour. Sometimes the subperiosteal new bone is laid down in thin irregular striations placed perpendicular to the shaft, resembling the "Sun-ray" appearance, thought to be characteristic of osteogenic sarcoma. The "Sun-ray" arrangement of subperiosteal new bone was seen in two of our patients in the frontal bones. The involved bone sometimes shows a combination of both the "Onion peel" and "Sun-ray" patterns of new bone formation. More often there is an irregular bizarre pattern of subperiosteal reaction.

From the radiogram alone, a differentiation of Ewing's tumour has to be made from a variety of bone lesions. These include osteomyelitis, osteolytic form of osteogenic sarcoma, metastatic bone deposits, reticulum cell sarcoma etc.

Histopathology

It is now widely accepted that a positive diagnosis of a malignant bone lesion requires the combined efforts of a surgeon, the radiologist and the pathologist. The pathologist is obviously the final arbiter. And yet often the pathologist does not arrive at a positive diagnosis

from his microscopic picture alone without reference to the skiagram and the clinical picture. Histologic diagnosis is not written on the slide. The microscopic appearance has to be interpreted. Leaving aside the personal factor, then the microscopic appearance, particularly with Ewing's tumour admits of different interpretation. A fair amount of polemical literature has collected about the nature of this bone lesion. Although most experienced oncologists following Ewing, accept this lesion as a distinct disease process, an emphatic opposition to such a view is voiced by some pathologists of repute *e.g.*, Willis, Colville, and Steruburg. They regarded all cases of Ewing as "precocious" metastatic bone lesions from an occult neuroblastoma either in the adrenal or the sympathetic ganglia. However Willis in his latest book "Pathology of Tumours" published in 1948, says "Some cases at least of Ewing's Syndrome are due to clinically obtrusive metastasis of neuroblastoma in long bones" (p. 864). One could ill afford to hold a dogmatic opinion on this count. The only course open is that of taking the "majority" view as a working hypothesis, always keeping in mind to look for data which go to disprove such hypothesis.

The cytological appearance of Ewing's tumour is fairly constant. It

shows "sheets" or groups of cells, with varying amounts of fibrous strands in between. The cells are usually round with some variation in size. Cell walls are indistinct with scanty cytoplasm and large hyperchromatic nuclei. Nuclei have well defined margins with scattered chromatin material. Sometimes the cells are polygonal when closely packed. Cells may be arranged along blood vessels and the R.B.C. may be separated from the tumour cells only by endothelium and delicate strands of reticulum, the so-called perithelial arrangement.

Occasionally the cells are arranged in "pseudo-rosette" formation. These are structures with circular arrangement of cells, nuclei of the cells being situated at their outer poles. Sometimes argyrophil reticulum fibres are seen scattered between groups of cells.

These microscopic appearances form the basis of a diagnosis of "Ewing's Tumour." This picture differs from the original description of the cell type by Ewing. He described it as "a small polyhedral cell with pale cytoplasm, a small hyperchromatic nucleus, and a well-defined cell wall." More recent reports (Stout and Jaffe) however describe cells to have a large nucleus, scanty cytoplasm and indistinct cell walls.

Jaffe and Leichtenstein do not ascribe any diagnostic significance

to the "perithelial" arrangement of cells. They state that hæmorrhage into the neoplastic tissue is accompanied by ingrowth of blood vessels. Many of these vessels become surrounded by tumour cells. According to them, the "vessel spaces are not lined by tumour cells." Besides they state that similar perivascular arrangement of tumour cells is seen in other sarcomas when focal areas have undergone extensive hæmorrhage.

The "pseudo-rosette" appearance in Ewing's tumour is a cause of much controversy. Similar structures are seen during development of sympathetic nervous system and frequently in the neuroblastomas arising from the adrenals and sympathetic system. Proper staining of these however will show neurites protruding from the central ends of the cells. The central cores will show fibrillar or granular appearance. Jaffe and Leichtenstein state that the cores of the so-called rosette arrangement in Ewing's tumour do not show a fibrillar or granular appearance, but are made up of degenerated cells with their wall sometimes perceptible. Oberling, is quoted by Stout to regard the formation of pseudo-rosette as due to degeneration and necrosis. The radiating arrangement of cells being explained on a purely physical basis. Stout, himself is not satisfied with this explanation. He says "orientation

of the nuclei towards the peripheral pole has a teleological aspect which suggests an activity other than pure degeneration. Consequently, their presence in the Ewing's tumour remains for me unexplained and in need of further elucidation."

Colville and Willis (1933) and Willis (1940) because of close resemblance of the cytologic picture of Ewing's tumour with metastasis from sympathetic neuroblastoma, warned against making a diagnosis of Ewing's tumour from clinical and biopsy data. Only carefully executed autopsies can exclude neuroblastoma. Without this a diagnosis of Ewing's sarcoma is not justified.

A perusal of the available literature on the subject shows that most experienced oncologists (Stout, Jaffe etc.) while accepting the weighty objections of Willis *et al* are inclined to regard Ewing's sarcoma as a disease entirely separate from metastatic bone lesion from sympathetic neuroblastoma, despite absence of autopsy examination in most of their cases and on the basis of the biopsy microscopic picture alone. Other lesions which often require to be differentiated from Ewing's tumour are reticulum cell sarcoma, lymphocytic lymphoma, and Hodgkin's disease. Sometimes bone metastasis from a silent highly malignant carcinoma may be the source of error, when microscopically it presents a uniform pattern of round cells,

Roentgen Picture in Ewing's Tumour

Vyankat G. Vohra.



FIG. 1-a. Before Irradiation.



FIG. 1-b After Irradiation.



FIG. 2-a. Before Irradiation.



FIG. 2-b. After Irradiation.

Roentgen Picture in Ewing's Tumour
Vyankat G. Vohra.



FIG. 3-a. Before Irradiation.

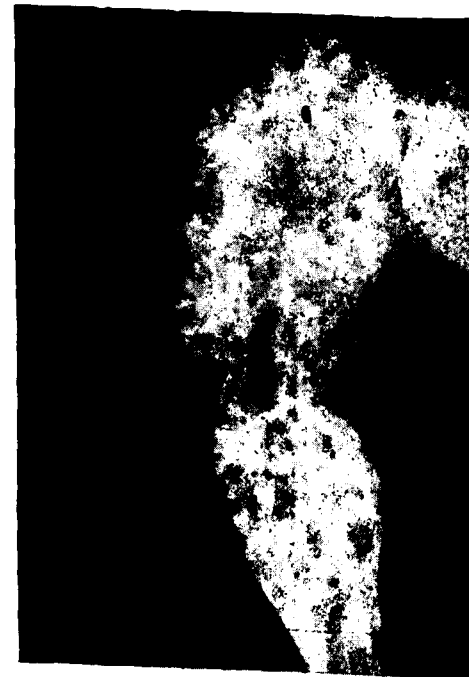


FIG. 3-b After Irradiation.



FIG. 4-a. Before Irradiation.



FIG. 4-b. After Irradiation.

Roentgen Picture in Ewing's Tumour
Vyankat G. Vohra.



FIG. 5-a. Before Irradiation.



FIG. 5-b. After Irradiation.



FIG. 6-a. Before Irradiation.



FIG. 6-b. After Irradiation.

Roentgen Picture in Ewing's Tumour
Vyankat G. Vohra.



FIG. 7. Pleo-morphic Appearance.



FIG. 8-a. P. A. View.



FIG. 8-b. Lateral: Showing involvement of Tibia and Femur.



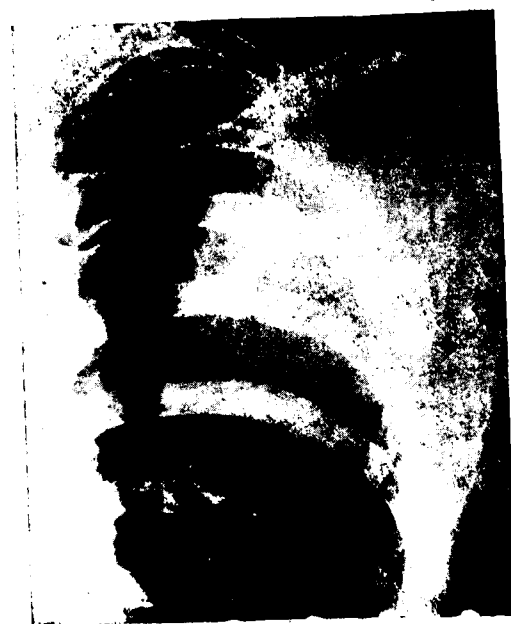
FIG. 9. Roentgen diagnosis of Osteomyelitis. Aspiration and formal Biopsy—Ewing's Tumour.

Roentgen Picture in Ewing's Tumour
Vyankat G. Vohra.



FIG. 10.

FIG. 11. Destruction of 3rd rib. Large soft tissue swelling.



Roentgen Therapy

Ewing's tumour, like Reticulum cell and Lipogenic sarcoma, is highly radio-sensitive. High radio-sensitivity in Ewing's tumour means a rapid initial regression of the tumour mass and not a complete control of the malignant process nor even in most cases an extended survival. With this high sensitivity of the tumour, theoretically it should be possible to obtain an extended survival if not complete cure by early adequate irradiation. Yet few "cures" are reported. The tumour is highly malignant and rapidly spreads to distant parts. The disease generally extends more along the medulla than is shown by the radiogram, so that treatment of the tumour area as shown by the radiogram would be inadequate. A large portion of the adjacent normal bone should be included in the field.

In most cases this would require inclusion in the field of the whole of the bone. A tumour dose of 4,500r at least is necessary. Woodard and Coley have recently reported that a tissue dose of 3,000 to 5,000r could control the tumour for varying periods; after this dosage a large number of viable tumour cells were still present. They report complete destruction of all tumour cells with tumour doses approaching 6,000 to 7,000r. Two of their patients so treated are living after eleven years.

This shows, that despite its apparent sensitivity, for complete control the tumour requires doses as high as does a squamous celled tumour. This would necessarily entail much damage to the skin and overlying soft tissues. A more serious consequence is damage to the normal bone. It is not generally realised that adult normal bone is more vulnerable to irradiation than surface epithelium. Besides it is now definitely established that absorption of penetrating radiations by bone is higher than in soft tissues. Very high tumour doses necessary to control Ewing's tumour will permanently damage the adjacent normal bone which has to be included in the treatment field.

Under irradiation the initial regression of Ewing's tumour is often amazingly rapid, with control of pain and marked reduction in soft tissue swelling. There is noticeable improvement in the general condition and the mental attitude of the patients. New bone formation becomes visible on the radiogram from about the third week of the commencement of treatment. During the 4th to the 6th week dense new bone becomes definitely established. The irregular cortical margins are smoothened and layers of dense bone are deposited along the shaft which may show hardly any evidence of malignant process.

All cases of Ewing's tumour do not show this high sensitivity. Some are definitely resistant. Two of our patients gave very poor response to irradiation. One of these, an eleven year old girl with involvement of upper tibial metaphysis had no reduction in pain or swelling. Patient died within two months with lung metastasis. An opportunity was afforded to us for noticing this radioresistance while treating two almost identical cases referred to us from the British Military Hospital in Bombay. Right ilium was the seat of disease in both with nearly similar roentgen appearance. Both were treated during the same period with identical deep therapy technique. One of these showed excellent response. Bone regeneration was seen within four weeks. The second patient had no reduction in pain. Soft tissue swelling was slightly reduced and patient gradually went down during treatment.

Our results of radiation treatment so far as extended survival is concerned are extremely disappointing. Twenty-two patients came up for

X-ray treatment. All of these except one, were treated with 200 kv. 0.5 m.m. Cu plus 1 m.m. AL filter, 50 cms. F. S. D.; and one was treated with 400 kv. 4 m.m. Cu plus 1 mm. AL filter 50 cms. distance. The doses ranged from 2400r (air) on each of the ports in case of long bones, to 3,000 and 3,500r on each of two ports in flat bones. Three of the treated cases were seen alive without metastasis for 1 year; after that there was no "follow up." There were seen up to 6 months without disease; then no follow up. Six patients died within three months of treatment. Six patients never came for follow-up after completion of treatment. One lived for two years but with metastasis in various parts of the body. We chased the disease from place to place with X-ray treatment, each time with excellent symptomatic improvement, till finally, the patient succumbed to extensive metastasis in the spine. Three patients, treated within last four months of 1947 are still living—two without metastasis and one with metastasis.

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Close Range Low Voltage X-ray Irradiation of Tumours rendered accessible by Surgical Exposure

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CHAOL-THERAPY has proved its worth in the treatment of tumours superficially located.

The special construction of the tube for Chaoul-therapy is particularly adopted to the treatment of tumours in cavities of the body because the anode is located at the end of a long and narrow shaft and may be inserted into any natural or artificial cavum (opened by operation). Tumours of the oral cavity (Chaoul), the vagina (Martius) and the rectum (Chaoul and Schatter) (Larru) have been treated successfully. The carcinoma of the vocal cords responds also to the intralaryngeal irradiation (Chaoul and Greineder.)

However the application of this method is not limited to the treatment of tumours directly accessible. In combination with a surgical exposure of the tumour first, the close range radiation may be applied to internal tumours. In this way Chaoul has treated with favourable results carcinomas of the rectum Levine, Pack and Galle have reported similar good results with urological cases.

Since 2½ years our efforts were directed in opening new domains of

indications for the utilization of this special method.

The superiority of the close range low voltage X-ray therapy to the percutan high voltage irradiation is indicated by three important advantages.

(1) No consideration to the tolerance of the normal tissues surrounding the tumour is necessary. The irradiation may be continued until the tumour is dissolved.

(2) The small volume dosage diminishes the undesirable effect of the irradiation on the tissues adjoining the tumour to a minimum. Thereby the functional, resorbing and regenerative abilities of the normal tissues will be preserved.

(3) The surgical exposure allows a clear diagnosis relating to location and size of the tumour.

The surgical exposure of the tumour has to be large enough in order to be subjectable to the following irradiation in toto and to avoid marginal residues.

Chaoul used the fractionated method principally in all cases of carcinomas of the skin; all the more reason to use the advantages of this fractionated method with internal

tumours, which are generally more malignant. This treatment requires a surgical exposure over a longer period of time. Proceeding this way serious disadvantages are not to be expected. Some of our patients with such an exposed tumour have to travel by rail regularly in order to be subjected to the irradiation. The therapy is generally well endured. The wound will be kept open until the dissolving of the tumour in toto can reasonably be expected. Then the wound will be closed and heals generally in short while without further reaction.

The dosage has to be high enough to guarantee the complete destruction of the tumour.

Usually we apply single doses of 500r and repeat these by daily irradiation 15 to 20 times.

In cases of deeply infiltrating tumours it might be necessary to administer even higher single or total dosages.

In certain cases of these deeply infiltrating tumours we apply in addition to the short distance therapy, larger fields of medium voltage irradiation with 200r, 10 to 15 times.

Cases of distant metastasis can not be treated successfully with this method. Under certain conditions we proceed in the same way as for instance in the therapy of cancer of the tongue with metastatic lymph-nodes on both sides—where both are

irradiated simultaneously. According to this method tumours of the following character have been subjected to treatment.

I. Rectal carcinoma.—After resection of the sacrum the margins of the opened rectum will be sewed to the skin. Then the tumour will be easily accessible. The irradiation has to be applied with intermissions for examination and might last from 10 to 12 weeks; thereafter the surgical restoration is performed. In this way Chaoul succeeded in 50% of his cases over a period of 3 years and more.

II. Inoperable tumours of the stomach and colon.—Successful experiments have been accomplished particularly in cases of tumours close to the cardia.

III. Carcinoma of the bladder.—They require an extremely high dosage. Shrinkage of the bladder is at times inevitable. But also in these cases helpful treatments have been reported. (Levine, Pack and Galle).

IV. Tumours of the parotid gland are especially well adapted to surgical exposure. After the incision the skin is turned aside and a high fractionated dosage applied. Local metastasis will be exposed also. Contrary to the surgical treatment of these tumours facial paralysis can and will be avoided.

Close Range Low Voltage X-ray Irradiation of Tumours rendered accessible by Surgical Exposure

Dr. G. Barth and Dr. F. Wachsmann



FIG. 1.
72 years old patient with metastases
at the angle of the jaw exposed:
Primary tumours.

[Vide page 119.]



FIG. 2.
Carcinoma of the cavity of the mouth.
Metastases and primary tumour healed.

[Vide page 119.]

Close Range Low Voltage X-ray Irradiation of Tumours
rendered accessible by Surgical Exposure

Dr. G. Barth and Dr. F. Wachsmann



FIG. 3.
Metastases of the groin.

[Vide page 119.]



FIG. 4.
Metastases healed.



FIG. 5.
Adjustment of an exposed tumour of
jaw cavity.

[Vide page 119.]

V. Local metastatic lymphatic nodes.—Particularly of the neck and inguinal regions did not offer previously a favourable prognosis. After exposure they present a special indication for the Chaoul-therapy. Particularly in these cases a wide incision is necessary to prevent a residue in the neighbourhood. The wound margins will be bent up and handled after the well known "round shape flap"—technic. After the dissolution of the tumour the skin is replaced and closed. Healing without complication will follow. (*vide Figs. 1-4*).

VI. Other tumours on the side and in the rear of the back as Retothel-Sarcoma and Bronchial-Tumours have to be treated as the local metastasis of the same localisation. In case of larger extension of the tumour additional fields of half-hard irradiation are applied. To prevent a detrimental effect caution has to be taken not to overdose the radiation.

VII. Thyroid-Cancer is also a subject of this therapy. Post-irradiation treatment requires careful consideration of the circulatory system according to our experience.

VIII. Tumours of the sinus maxillaris are another indication for a successful treatment. The surgical procedure is going through cheek and exterior wall of the sinus, thereby giving a clear view of the tumour localisation. This method is

considered superior to the section of hard palate or to the Luc-Caldwell's operation since no difficulties will be encountered with the adjustment of the applicator. (*vide Fig. 5*).

IX. Tumours of the nose (affecting septum and turbinate) will be attacked advantageously with the pointed anode tube introduced through the opened lateral nasal wall.

X. Tumours of the middle and internal ear have undergone effective treatments by this method.

XI. Tumours of the larynx.—This sort of growth, when confined to the vocal cords, is healed relatively secure and without reaction when subjected to close range X-ray therapy. More extensive tumours have to be exposed by a thyrotomy—in order to be well accessible.

Summary.—At the present we are able only to report primary healings, since we are performing the method described above for about 2½ years. However many of our patients are free of symptoms over long intervals already. This condition could not have been obtained by utilization of the percutan (high voltage) method. Our past experiences lead to the conclusion, that a decidedly helpful therapy of the combined method may still be possible in cases, which previously have been beyond hope.

Exact details of procedure of this method will be available at request.

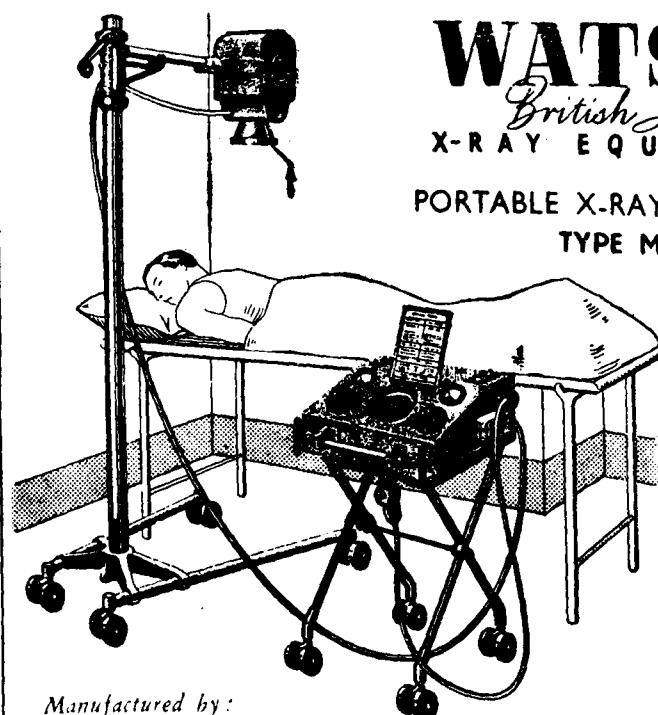
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Incorporation of Built-In Protection from Radiation—Madras-Method

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Introduction.—This article gives a new method introduced at the Barnard Institute of Radiology, Government of Madras in the years 1932-1934 in the construction of special rooms in which are housed the high voltage X-ray plants and Radium. The method of protection afforded by the materials used in the construction of the rooms is discussed in detail and a comparison is made with other methods to explain that the Madras method is an easy one, at the same time cheaper than the rest (especially now when the cost of building materials is still soaring high) and more efficient in its protective value. This method can easily be adopted in any part of India with advantage in the matter of protection and benefit in the matter of economy and considerable saving in expenditure on buildings for radiological institutions.

Protection-old methods.—International Committees on protection have laid down a list of precautions which should be followed by those in charge of radiological departments to protect the working personnel engaged in radiation work and the most important of these precautions is the provision of adequate protec-

tive materials between the personnel and the source of radiation. Lead is the oldest known protective material and to adopt heavy sheet lead lining of suitable thickness for absorbing the radiation has been found to be "Prohibitive and the whole arrangement impracticable."

With the advancement of more knowledge on protective values of materials, this difficulty was to a certain extent solved by introducing some substance in the building material itself so as to incorporate what may be described as "built in protection." After several experiments, it was found that Barium Sulphate (Barytes) gives good protection and it is easy to procure the same in large quantities. Several proportions were tried and the Radiological Department of the Edinburgh Royal Infirmary was the first Institution to be built with this protective material in the year 1926.

The incorporation of barium slabs in the construction of its buildings was given effect to. The slabs were 24" x 12" x 3" in size and were made in the proportion of 1 part of Rough sand, 2 parts of Engine Ash, 1 part of Portland cement and 3 parts of Barium

sulphate. These were supplemented by barium plaster on either side $5/8$ " thick, which is composed of 3 parts of rough sand, 1 part of Portland cement and one of barium sulphate. The finished walls, it is stated gave protection equivalent to 5 mms. of lead, as certified by the National Physical Laboratory, Teddington, England. This method is not free from objection, one of which is that the sizes of the room would be reduced by the thickness of slabs.

The Madras-method. — Captain T. W. Barnard, the founder Director of the new Radiological Department of the Government General Hospital, Madras, named in his honour as the Barnard Institute of Radiology by the Government of Madras in appreciation of his valuable services in the field of Radiology in the Madras Presidency, was faced with the problem of providing adequate protection, when the new buildings of the Institute were built in the year 1932-1934, as a part of the general remodelling scheme of the Government General Hospital. He had several proportions of the Barium Sulphate tried out. "Why not this barytes be incorporated in the ordinary brickwork itself?" This idea engaged his attention and he successfully found that ordinary bricks can be impregnated with the barytes to get the requisite protection and that the same can be

further increased by using a special barium plaster. Two types of barium bricks and one kind of special plaster were made and these were sent to the National Physical Laboratory, Teddington for test and report.

Preparation of the special bricks.—Clay used for the special bricks consists of ordinary brick earth absolutely free from any pebble and vegetable matter. The dry earth should first be collected in a brick platform and the clods broken so as not to contain any lumps larger than 1" or $1\frac{1}{2}$ " sizes. The clay should then be measured by a wooden 'para' or measure. The barium sulphate (ground to extreme fineness so as to pass through a sieve of nearly 300 meshes to the inch) is then added to the clay in the proportion of one part by volume of barium sulphate to eight parts by volume of clay, (1:8) and the whole turned over dry twice as it lies on the platform. In order to ensure proper mixing, not more than 20 c. ft. of clay should be taken up in a heap for mixing at a time. All such heaps are then collected together and a pit formed in the big heap. The requisite quantity of water should then be poured in the pit slowly and the whole allowed to remain for 12 hours. The mixed clay after being pugged carefully as is usual for ordinary bricks is then ready for moulding and burning.

The process of mixing and moulding should be done under proper care and supervision.

After burning, it was found that these bricks were harder and of course heavier than the ordinary brick of the same size. A barium impregnated brick weighed 5.75 lbs. as against 5 lbs. of ordinary brick work.

The materials sent for test to the National Physical Laboratory were as follows:—

(1) X. R.—Barium Brick table moulded and of size $9" \times 4\frac{1}{2}" \times 2"$ —The proportion of barytes to clay is 1:8 by volume.

(2) S. B.—Special Brick—Table moulded and of size $8\frac{1}{2}" \times 4\frac{1}{4}" \times 3"$. The proportion of barytes to clay is 1:2 by volume.

(3) Special Plaster—Constituted by 3 parts of Barytes, 1 part of Sand 1 part of cement. This contained 85% of barytes by weight and in conjunction with cement proved a good plaster. About $2/3$ of the barytes used was coarse and the remainder finely ground. (As suggested in an article by G. W. C. Kaye in the *British Journal of Radiology*, September 1928).

Using these types of bricks and plaster, the elaborate lining of the walls with special barium slabs as in the case of the Royal Infirmary Edinburgh was given up to the

advantage of greater protection and cheaper cost in construction.

The N. P. L. Report on the Bricks.—The Director General of the India Stores Department, through whom these bricks and plaster were sent for test to the National Physical Laboratory, in a reference stated "that the actuals (bricks) are of excellent mechanical quality."

The Report of the National Physical Laboratory is given below:

Ref.:—R 1631—dated 24.9.1931.

"The eight samples of materials submitted for test have been examined at various points for their X-ray protective qualities."

The thickness of lead of which the X-ray absorption is equal to that of each sample is given in the following tables. (*Vide Tables I, II and III page 123*).

The radiation was emitted by a Tungsten anode.

It is seen from Table I, that $1' 1\frac{1}{2}"$ wall gives a protection of 6.4 mm. of lead. (In this connection it is of value to bear in mind for comparison purposes that 9 inches of ordinary brick has a lead equivalent of $1\frac{3}{4}$ mm. approximately).

From Table I, another Table, showing the equivalent thickness of lead per cm. of brick work is prepared.

TABLE I.

Materials	Distin- guishing mark on sample	Thickness	Voltage on bulb (constant potential)	Equivalent thick- ness of lead to nearest 0.1 mm.
Bricks with admixture of BaSO ₄ .	0.05	2.1 c.m.	200 K. V.	0.5 mm.
"	0.10	3.5 "	" "	0.8 "
"	0.15	5.0 "	" "	1.0 "
"	0.20	7.0 "	" "	1.3 "
"	0.40	13.6 "	" "	2.6 "
"	0.60	20.5 "	" "	3.9 "
"	0.80	27.5 "	" "	5.1 "
"	1.0	33.3 "	" "	6.4 "

TABLE II.

Thickness of Barium Brick	Equivalent thickness of lead protec- tion	Equivalent thickness of lead protection per centimeter of barium brickwork
2.1 cms.	0.5 mm.	0.24 mm.
3.5 "	0.8 "	0.23 "
5.0 "	1.0 "	0.20 "
7.0 "	1.3 "	0.19 "
13.6 "	2.6 "	0.19 "
20.5 "	3.9 "	0.19 "
27.5 "	5.1 "	0.185 "
33.3 "	6.4 "	0.19 "

From Table II, it is seen that the protection per cm. of barium brickwork is greater below 5 cms. *i.e.* 2". Above this, the protection obeys a straight line graph as the same per centimeter is constant. Since no brick work will be below 2", the working portion *i.e.*, the practical aspect of the problem lies on the straight line part.

The National Physical Laboratory reported that the special barium

plaster as detailed above, is such that $\frac{3}{4}$ " thickness of special barium plaster gives a protection equivalent to 0.8 mms. of lead. It is evident that such high equivalency of protection is due to the large proportion of barium, which proportion has the advantage for protection purposes.

The various protective lead equivalents of the walls constructed by using

(1) Ordinary concrete.

(2) Barium bricks (1 part of BaSO₄: 8 parts of clay) plus $\frac{3}{4}$ " of special barium plaster (3 parts of BaSO₄ plus 1 part of sand and one part of cement) on either side.

(3) Barium bricks (1 part of BaSO₄ plus 2 parts of clay) plus $\frac{3}{4}$ " of special barium plaster (3 parts of BaSO₄ plus 1 part of sand and one part of cement) on either side of the walls are shown in the following Tables

III, IV and V. They are also graphically represented (Graph A).

Walls constructed with
(1) Ordinary concrete.

TABLE III.

Concrete wall thickness in inches	Lead pro- tection in inches	Equivalent lead protec- tion in mm.
4	0.05	1.27
10	0.137	3.40
14	0.225	5.72
19.5	0.550	13.97

TABLE IV.

(2) Barium bricks (1:8) plus $\frac{3}{4}$ " special barium plaster on either side of the wall.

Thickness of wall due to barium bricks (in inches)	Thickness of wall due to barium plaster (in inches)	Total thick- ness of wall (in inches)	Equivalent lead protection due to both in mm.
3.0	1.5	4.5	1.4 + 1.6 = 3.0
8.5	1.5	10.0	4.0 + 1.6 = 5.6
13.5	1.5	15.0	6.4 + 1.6 = 8.0
18.0	1.5	19.5	8.5 + 1.6 = 10.1

TABLE V.

(3) Barium bricks (1:2) plus $\frac{3}{4}$ " special barium plaster on either side of the wall.

Thickness of wall due to barium bricks (in inches)	Thickness of wall due to barium plaster (in inches)	Total thick- ness of wall (in inches)	Equivalent lead protection due to both in mm.
3.0	1.5	4.5	4.3 + 1.6 = 5.9
8.5	1.5	10.0	12.0 + 1.6 = 13.6
13.5	1.5	15.0	19.2 + 1.6 = 20.8
18.0	1.5	19.5	25.5 + 1.6 = 27.1

From the above Tables, the following facts are obvious.

I. (1) a 14" concrete wall gives a protection equivalent to 5.72 mms. of lead.

(2) a 13.5" wall built with barium bricks (1:8) and $\frac{3}{4}$ " special barium plaster on either side gives a protection equivalent to (6.4 plus 1.6) = 8 mms. of lead.

(3) a 4.5" wall built with special barium brick (1:2) and $\frac{3}{4}$ " special barium plaster on either side gives a protection equivalent to 5.9 mms. of lead.

This is nearly the same given by a 14" concrete wall.

II. 6 mms. of lead protection can be had by either.

(a) 14.2" of concrete wall, or

(b) 10.8" of ordinary barium brick plus special plaster on either side or

(c) 4.5" of special barium brick plus special plaster on either side.

From a study of these, it can be concluded that to get any required thickness of walls, these special bricks can be backed

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up by ordinary bricks. It is better in such cases to see that all the bricks are impregnated not with the heavy proportion *viz.*, 1:2 but with the lighter proportion *viz.*, 1:8. For partition walls the heavy proportion is the best, as these with the special plastering gives a large protection at a small thickness.

The Rooms at the B. I. R.—In the special room for protection at the Institute, the size of the bricks impregnated with barium sulphate was kept the same as that of country bricks which were being used in the building so as to facilitate proper binding between these special bricks and ordinary bricks in a wall of greater thickness than 1' 1½". The slabs made for the Radiological Department at the Royal Infirmary Edinburgh contain 20·45 lbs. of BaSo₄ per square foot of wall surface. It was decided to give the same protection in the Institute walls in a thickness of 1' 1½".

BaSo₄ was added to lime mortar in the proportion of 1 : 8 by volume and the whole was mixed together well and then used in the work of plastering. For walls of 1' 1½" wide, barium impregnated bricks were used throughout the full width and in walls of more than 1' 1½" and 1' 6" width in alternate courses and the balance in the width was built in ordinary mortar.

There were certain partitions which required to be provided the same amount of protection as the main walls. The partition being only 3", the bricks used for the wall did not give sufficient protection. So the special barium bricks (1:2) were used, after test, which showed that 3" of the special brick is of the same density as the 13½" of X. R. bricks (1:8). And so these were safely used for partition in the X-ray and radium rooms.

The plastering was done by mortar constituted by 1 part of cement 1 part of sand, and 3 parts of BaSo₄ and the thickness of the plastering was ¾" to 1" laid in the same manner as two coats of ordinary lime plastering. Care was taken to see that the ingredients were mixed quite well before the mortar was applied to the walls. All the walls and partitions built with barium impregnated bricks were treated with the above type of plastering. All these as a finished wall gave a protection equivalent to 8 mms of lead.

Thus, by using the bricks and plaster adopted by Captain Barnard, protection according to our requirements can be had at a smaller thickness and at a cheaper cost than by other methods.

The comparative thicknesses which give the same 6 mms of lead protection and the relative cost in the

years (1932-'34) in rupees per 100 sq. ft. of the wall work are graphically represented. (Graphs B, C and D.) The present day cost is not worked out as the prices fluctuate. Also it is not necessary, as the ratio of the cost remains the same, as the price of all materials have gone up, proportionately.

Messrs. Kaye, Binks and Bell of the National Physical Laboratory, Teddington have published some of their experiments on the protection equivalent of materials (*British Journal of Radiology*, Vol. XI,

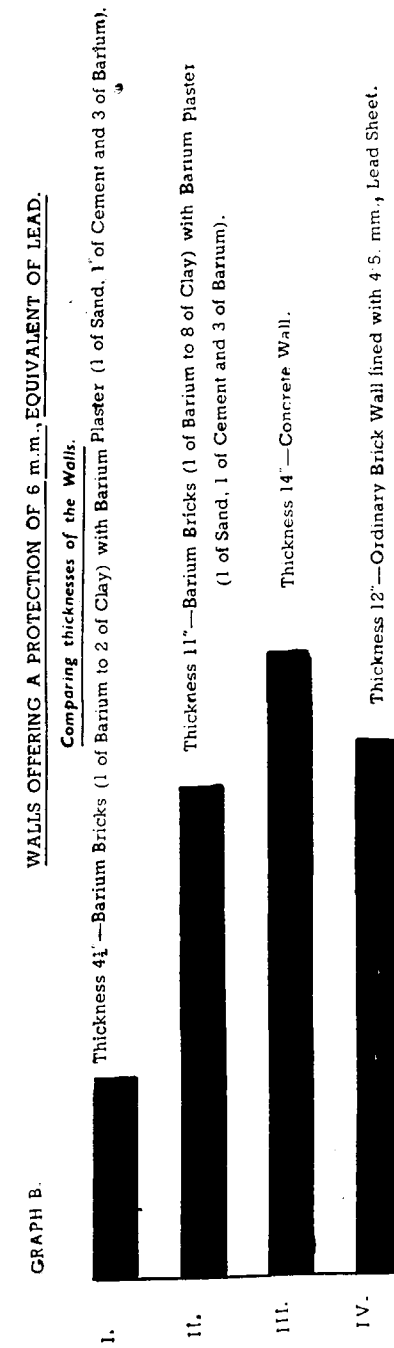
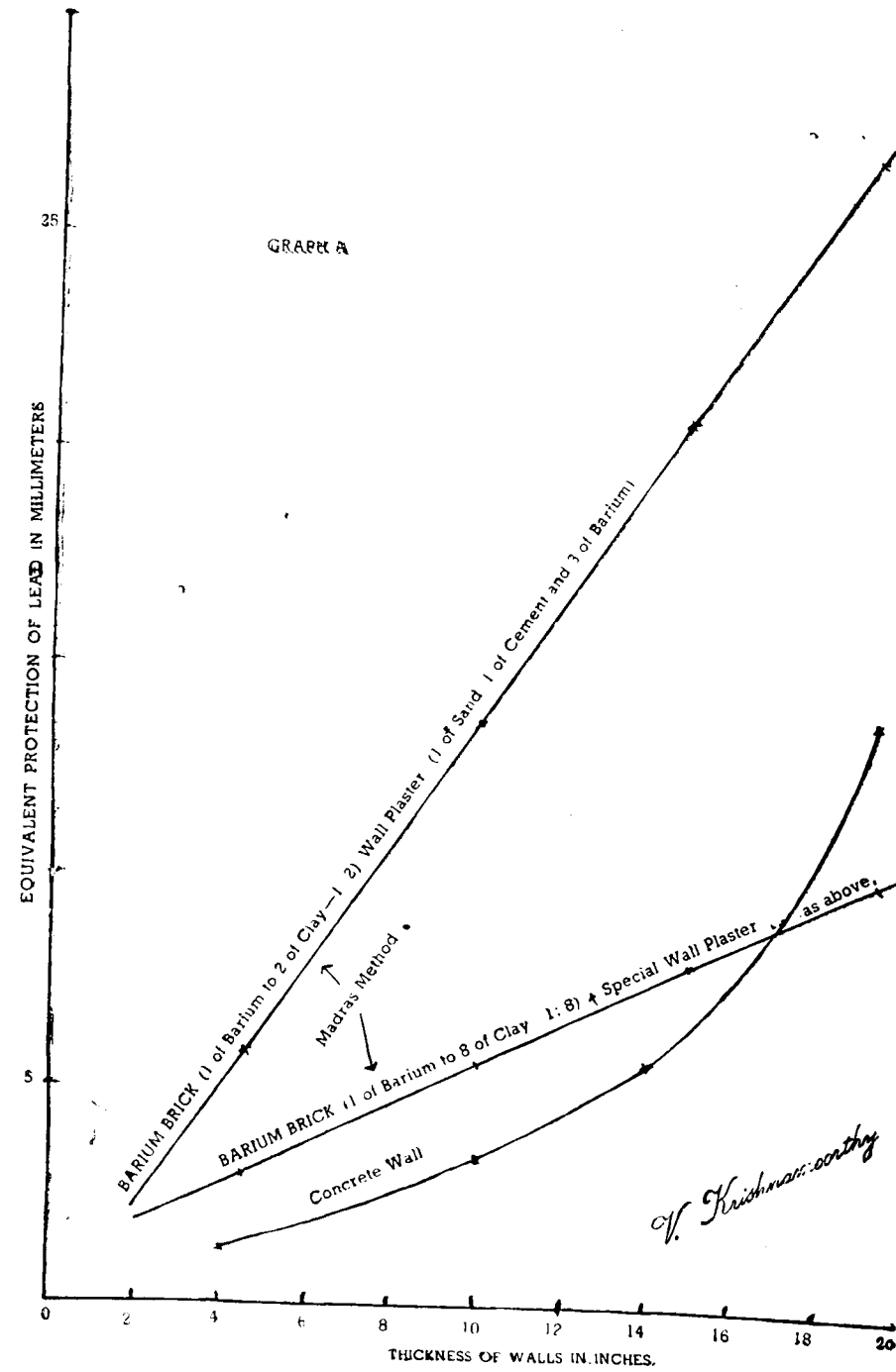
No. 130, October 1938, pages 676-685).

They have compared ordinary concrete, barium concrete and iron and other bricks for their protective values at different voltages.

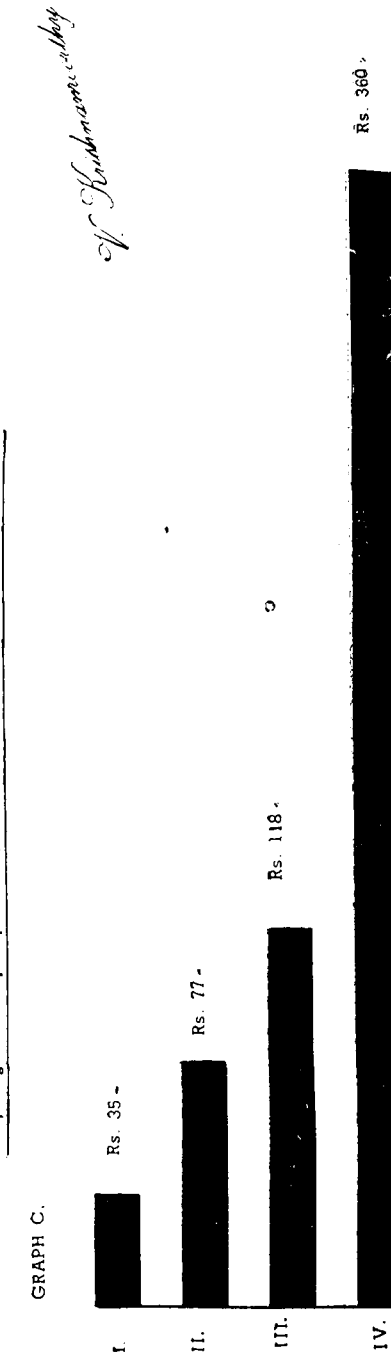
The report given by the National Physical Laboratory for Captain Barnard's bricks and plaster is for 200 k. v., and as such the field of discussion of his results with theirs is limited. However, the lead equivalent protection at 200 k. v. alone is reproduced here for reference.

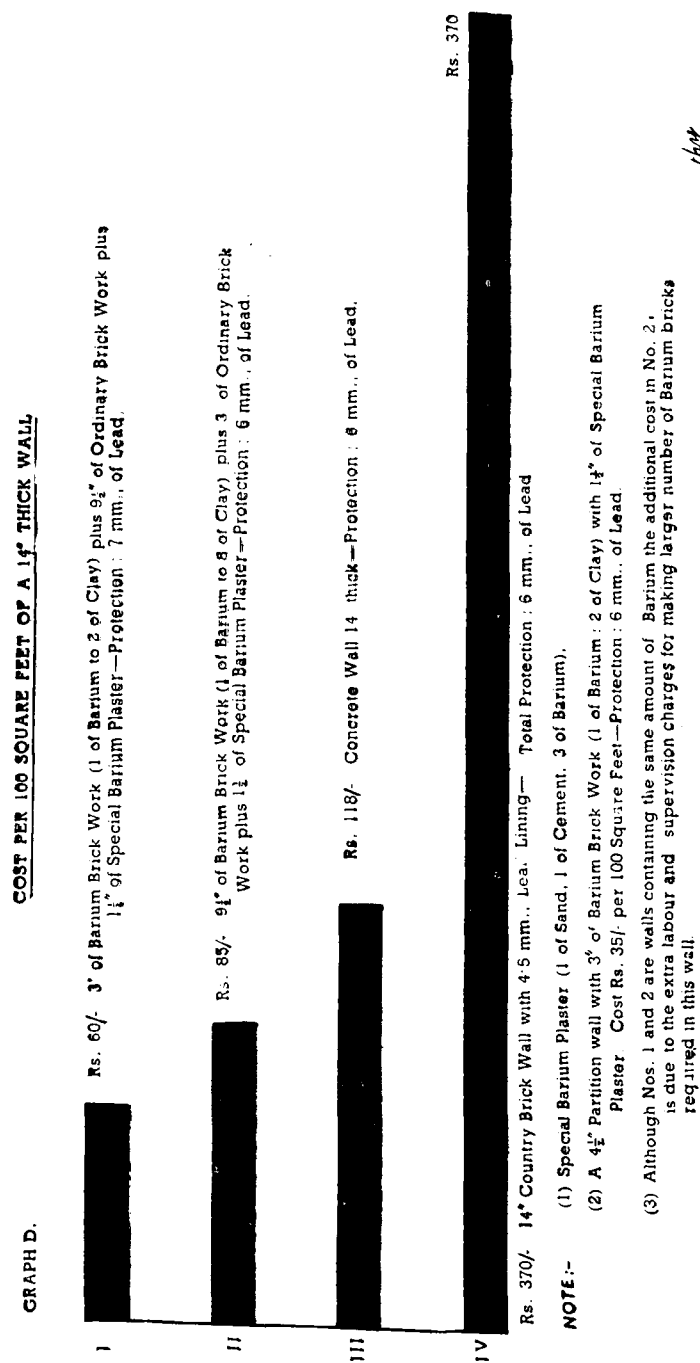
TABLE VI.

No.	Materials	K. V.	Lead equivalent in mms.	Corresponding thickness of materials	
				In cms.	In inches nearly
1	Concrete (2 of ballast + 2 of sand + 1 of cement.	200	1	8·0	3·2
			2	15·0	6·0
			3	21·0	8·4
			4	27·5	11·0
2	Ba concrete. Either 2 of barytes coarse + 2 of " fine + 1 of cement or 1 of barytes coarse + 1 of " fine + 1 of cement	200	1	1·4	0·56
			2	3·0	1·2
			3	4·5	1·8
			4	6·0	2·4
3	Ba concrete. Either 2 of barytes coarse. + 2 of sand + 1 of cement or 1 of barytes coarse + 1 of sand + 1 of cement	200	1	2·2	0·88
			2	5·0	2·0
			3	7·5	3·0
			4	10·0	4·0



Comparing cost in Rupees per 100 Sq. Ft. of the Walls for the Corresponding thicknesses.





There is a question of concrete, whereas the Madras method is one of bricks and the impregnation of barium is in the ordinary brick itself which *saves the cost of cement*. The comparative values for gamma radiation protection are not available and hence not discussed here.

The Madras method serves the purpose of a *reasonably equivalent lead protection at a reduced cost*. It may be stated here that Captain Barnard, by this method nearly saved Rs. 80,000 for the Government of Madras.

And this method can be made use of in the building of new Radiological Institutions.

Summary.—Various developments

in the building of X-ray rooms with adequate protection for the working personnel are discussed. The incorporation of the protective material in the building material itself has been given effect to in what is described as the "*Madras-Method*" to the replacement of the olden days' method of lining the walls with sheet lead and building walls in concrete. Several proportions of barytes, the protective material with their lead equivalent values are discussed.

The Madras-Method of using impregnated barium bricks stands a good test of protective value and is recommended both from a point of view of high efficiency of protection it offers and the relatively low cost in construction.

The Supervoltage X-Ray Generator at Sheffield

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IN 1945 Mr. James Morrison of Sheffield created a Trust Fund in memory of his brother David, to be used in improving the treatment of malignant diseases by X-rays. As a result of this generous gift a new department was planned at the Sheffield National Centre for Radiotherapy. This department, known as the David Morrison Research Department, houses a new supervoltage X-ray machine working at 2 million volts. The new apparatus represents a great advance in radiotherapeutic practice and a very interesting application of modern electrical technique to the medical field.

Great hopes are held that the use of very high voltages for X-ray production will give real improvement in the treatment of deep seated tumours. These hopes are based on the very substantial increase in the ratio of tumour dose to skin dose that can be obtained in the super voltage field. There are three factors contributing to this effect. The first is that the high efficiency of X-ray production at high voltages allows greater distances between skin and target of the X-ray tube. The second is that the radiations themselves have a greater penetrating power. These

two effects both give an improved percentage depth dose as normally understood. The third factor, and probably the most important one, is that at higher voltages, the peak ionisation occurs at an appreciable depth below the skin. This is due to the fact that until a depth is reached nearly equal to the electron range in the tissue, equilibrium is not attained between the electromagnetic radiation and the associated electrons.

The ideal voltage for therapeutic treatment of deep tumours is still a matter of discussion. Using multiple field techniques it is probable that the best voltage is not greater than 10 million, since above this the X-ray beam becomes more and more confined to a small angle with respect to the incident electron stream. The exit skin dose also rises seriously.

At 2 million volts the radiation quality is such that with an effective filtration of 9 mm. lead equivalent, the half value layer is about 8.3 mm. of lead. This is just slightly greater than the half value layer of the gamma rays from radium filtered with 0.5 mm. of platinum. The percentage depth dose at 10 cm. deep, obtained in a field 9 cm.

square with 1 metre focus skin distance, is 52% for 2 million volt radiation. Compared to this, only 30% is obtained with a similar size of field at 50 cm. from the target with a beam of 200 k. v. The electron range at 2 million volts is sufficient to cause the peak ionisation to occur at about 3 mm. below the skin and to have a magnitude about 2.5 times the value at the surface. These figures are quoted from the published measurements of Professor John Trump of the Massachusetts Institute of Technology. These physical data clearly indicate that at 2 million volts real improvements over routine therapy can be anticipated, especially in the ability to give a lethal dose to a tumour with only very small skin reactions.

The generator now installed in Sheffield, has been built by the High Voltage Engineering Corporation of Cambridge, Massachusetts and is a development of the electrostatic generator originally devised by Professor Van de Graaff. It is to Professor Van de Graaf and his colleague Professor Trump at the Massachusetts Institute of Technology, that the credit is mainly due for the development of the new instrument. The production of the unit in its final form for clinical work owes much, too, to the work of the staff of the High Voltage Engineering Corporation.

In contrast to the enormous size of the earlier electrostatic generators, the new machine is contained in a tank small enough to be installed in a reasonable sized treatment room, and it can be orientated easily in any direction between the horizontal and the vertical positions. The treatment room in the David Morrison Department is 22 feet square.

The insulating column supporting the high voltage terminal consists of a stack of aluminium electrodes separated by glass insulators, the whole being bonded together by a plastic material. Its diameter is 39 cms. and there are altogether 42 electrodes. This column is surmounted by a stainless steel hemisphere.

The main column is assembled on a substantial steel base which also carries the motor to drive the charging belt. The X-ray tube is also mounted on the base inside the insulating column with its axis parallel to the axis of the column. Underneath the base is a massive cylindrical lead block into the centre of which fits the lower end of the X-ray tube carrying the anode. This is a transmission target and the purpose of the lead block is to absorb unwanted radiation emitted in any direction, except forward, at a small angle to the incident electron stream. The

tank enclosing the insulating column is bolted down to the base, the tank and gasket being designed to stand the high pressure of the insulating gas of about 27 atmospheres.

From the point of view of satisfactory clinical use, it is necessary that the tank itself shall be of not too great a physical size and weight and that it be reasonably easy to orientate. The total weight of the tank and its internal structure is about 3,000 lbs. It is supported in the Sheffield installation by a cradle moving vertically inside a mount fixed to the ceiling. The height of the room in which the machine has been installed is 15 ft. With the tube pointing vertically downwards a focus-skin-distance of 1 metre can be obtained with the skin at a height of 40 inches from the floor. From this extreme position the tube can be tilted through 90° and lowered so that the beam may be fired horizontally at a height of 32 inches from the floor. The lift and tilt mechanism are controlled by a pressbutton switch on a flexible lead so that they can be operated easily by the radiographer adjusting the patient to the correct position.

In the Sheffield arrangement protection problems have been relatively easy since the set is installed in a new single storey building on an open site. The main beam when firing horizontally, is directed at a wall 39

inches thick, of which thickness, 25 inches is of barium loaded concrete and the rest stone. Other walls of the room are 21 inches thick, consisting of 10 inches of concrete with the rest of brick and barium loaded plaster. The walls are continuous up to 7 feet 6 inches, but very adequate lighting is obtained by windows above this level. The control desk is placed behind the 21 inches thick rear wall of the treatment room, and observation of the patient is by means of a periscopic mirror arrangement.

The generator is designed to give a working electron beam of 250 microamperes and the X-ray output measured in air at 1 metre from the target is about 50r/min. Under these conditions the direct beam is reduced by the thick wall mentioned to about tolerance dose rate at 12 feet from the target. The dose received at the control desk is due mainly to radiation emitted from the target, and penetrating the lead shield round the target or the tank surrounding the tube. Only a small proportion is due to scatter from objects irradiated by the main beam. The shielding round the target itself is designed to reduce the direct beam to an intensity of 10 times tolerance at 10 ft. distance. Behind the 21 inch concrete wall a dose rate of less than one tenth of tolerance is achieved.

The area of the irradiated field is adjusted by means of two sets of

lead blocks moving at right angles to each other. This beam defining assembly is mounted on the end of the massive shielding structure round the target. It can rotate round the beam axis so as to obtain at a metre from the target, fields of rectangular shape whose sides vary from zero to about 30 cm. A light reflected by a stainless steel mirror is used to indicate the area covered by the X-ray beam.

The panel from which the generator is controlled is a compact, easily serviced, assembly in a cabinet 24 inches wide, 22 inches high and 16 inches deep. This is mounted on top of the flat control desk. On the control panel are located the switch for the motor that drives the belt, and the switch for activating the unit which sprays charge on to the belt, this later acting as the radiation control. The meters on the panel include a direct reading voltmeter and an integrating dosimeter. The voltmeter is a generating voltmeter mounted in the tank opposite to the high potential terminal, and the dosimeter works from a thimble ionisation chamber in the beam defining-system just below the target.

Servicing of the new generator during routine operation is particularly concerned with two parts of the gear, first the continuously pumped X-ray tube and second the charging belt.

The X-ray tube, which is a multisectioned assembly using glass insulators and aluminium electrodes, is pumped through a hole in the base plate of the tank, connected by a long flexible metal hose to a mercury diffusion pump. In this way the movement of the tank to point the X-ray beam in the required direction is not restricted. The use of mercury in the diffusion pump, instead of oil, necessitates the use of a refrigerant. Solid carbon dioxide is used in a large trap directly on top of the pump. In order to keep the tube well conditioned the vacuum system is left pumping continuously. It is therefore necessary to give daily attention to the cooling trap. Under normal conditions the consumption of something like 6 to 10 lbs. of solid carbon dioxide per day must be allowed for, and a constant delivery of refrigerant to meet that need has to be arranged. The whole of the vacuum pump assembly is mounted in a fixed position relative to the axis of support of the tank and moves vertically with the generator. For cooling the diffusion pump a flow of water of about $\frac{1}{2}$ gall. per minute is required in addition to the 1 gall. per minute for target cooling and tank cooling.

Under routine conditions of work the tank would have to be removed periodically for general cleaning of the assembly, and for renewing of the belt. The life of the belt

itself under normal clinical work is not yet known but is in the region between 200 hrs. and perhaps 600 hrs. The time the set will be out of action for work to be done on the inside, or for a belt change is ordinarily less than 24 hours. This time is determined almost completely by the necessity to ensure very thorough drying of the inside before the tank is repressurised. For this purpose the tank is evacuated for at least 12 hours through a mass of silica gel. It is convenient for this evacuation procedure to take place overnight. The gas filling of the tank is approximately 50% nitrogen and 50% carbon dioxide. This is introduced from commercial gas cylinders through a second container filled with a mass of silica gel drying agent. The whole filling up to 375 lbs. takes a little less than 2 hours. The belt changing procedure involves removal of the top pulley and a set of belt spacing guides from each equipotential plane. The resistances which form the potential dividing net work between the planes must also be removed. The total time to remove a belt and insert a new one is about 2 hours. It is not expected therefore that very serious interruptions of a clinical treatment programme will be experienced for servicing.

The drying agent, pump for evacuating the tank, and hot air blower for reconditioning the silica gel dry-

ing agent are housed together in a mobile assembly known as the gas handling unit which measures roughly 32 inches by 25 inches with a height of 36 inches. This unit is also capable of supporting the very heavy lead pot and beam defining assembly which surrounds the target, in case this has to be removed for any purpose.

Apart from the gas handling unit as just described the only other auxiliary apparatus necessary for running the generator is a small trolley on which the base plate rests when the tank is lifted from it. This enables the vertical lift of the mount to be used for the removal of the tank. The base itself with the assembled insulating stack can be moved away from the mount for servicing.

A small space for handling the gas cylinders is a convenience since normal X-ray treatment room is not well adapted for this purpose. For each filling 2 or 3 cylinders of carbon dioxide and 3 or 4 of nitrogen are used, and in Sheffield these will be handled in a small out-building, the gas passing into the treatment room at high cylinder pressure, with the mixing and pressure reduction valves installed inside this room.

The two photographs show the generator at Sheffield in its final assembled form (*Fig. 1*) and with the tank removed for servicing (*Fig. 2*).

The Supervoltage X-Ray Generator at Sheffield

H. Miller



FIG. 1.

[Vide page 136.]

The Supervoltage X-Ray Generator at Sheffield

H. Miller

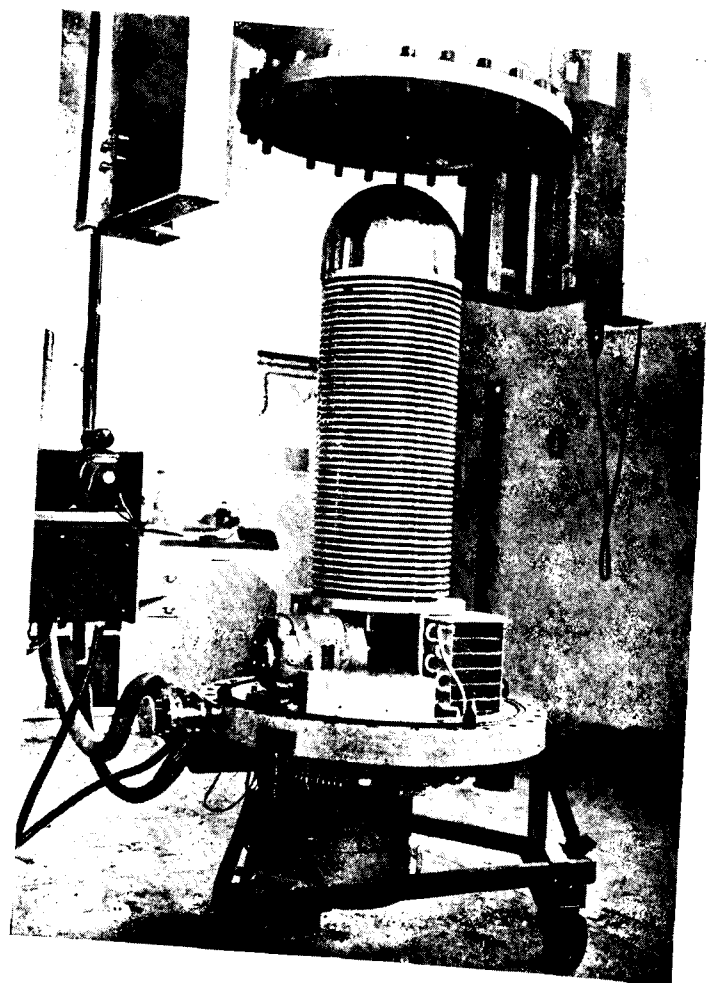


FIG. 2.

[Vide page 136.]

In Fig. 1 the method of mounting is clearly illustrated. The photograph also shows the beam defining and target screening assembly projecting from the base of the tank, and the gear for pumping the tube. This pumping unit is attached to the bottom of the left hand limb of the movable carriage of the mount. The flexible metal hose used for pumping the tube can be seen terminated at the tank base by a vacuum valve on the left of the tank base. Cables carrying the control leads, water feeds and power supplies are also seen.

In Fig. 2, the insulating stack

surmounted by its stainless steel dome is seen. The vacuum valve at the left of the base plate is also again visible. On the base plate is shown the motor to drive the belt and the heat exchanger for cooling the gas inside the tank. The whole assembly on its base is shown resting on the trolley used for servicing.

At the moment the choice of apparatus available commercially for supervoltage therapy is very limited. The generator described, however, represents a very successful achievement in the production of a suitable medical unit in the 2 millions volt range.

Storage of X-ray Films in Tropical Countries

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THE main effects of deterioration upon unexposed sensitized material are 'fogging' and loss of sensitivity due to long storage and unfavourable climatic conditions. In tropical countries there are innumerable difficulties to face. Warm, humid atmosphere promotes the growth of fungus whilst a hot, dry climate may cause cracking of the celluloid base. A further possible tropical storage hazard to be considered is the penetration of the wrapping surrounding the film by moisture. This can be the result of rapid temperature changes or the presence

of a naturally high percentage of humidity in the atmosphere. The effect of this is to lower the sensitivity of the film with general fogging. Furthermore, the black paper folder around the film, due to absorption of moisture, again causes variations in the sensitivity of the film which, on processing, shows as a mottling. One other effect has been encountered and is possibly attributable to the same cause. In this instance the black paper folder shrinks and takes up characteristic ripples or corrugations as a result of the breaking down of the size that the paper

contains. This always occurs across the short axis of the paper and leaves the film, after processing, with broad lines of varying densities. Film manufacturers have taken steps to prevent such occurrences and it is now usual for the films to be enclosed in what is known as tropical packing. This is in addition to the normal wrapping and tends to safe-guard the film against moisture.

As an extra precaution the boxes of films may be sealed in metal containers which are transhipped in hermetically sealed cases. On reaching the tropics it is common practice for these containers to be stored in a special chamber in which the temperature and humidity are controlled. On removal from the chamber it is necessary to allow the films to attain the outside temperature before opening the containers, otherwise condensation will take place leaving the surface of the films moist. To prevent this the containers are removed from the cold room at least 24 hours prior to despatch or use.

On arrival at the hospital the X-ray films should be immediately stored in a cool room and not in a cold chamber or refrigerator. It is considered that the latter mentioned forms of storage require expert handling to avoid heat fog produced

as a result of rapid variation in temperature as well as the danger from condensation spoken of earlier. The ideal temperature of the cool room should not exceed 80°F. As this is not always possible, the films should be stacked in the coolest place and preferably away from outer walls. Furthermore, the boxes of films should be stacked upright when in storage and not left lying flat as the pressure of one box on another will produce heat and fogging of the films will commence immediately. If it is decided to keep the films in cold storage, the temperature should approximate 55°F with a humidity of 50%. The films should remain in their original packing as long as possible and at all times, should the repacking of unexposed films in other than the original wrappings be avoided as commercial cardboards and papers may contain silver solvents which act upon the sensitized emulsion of the film.

Finally, the films should be stored away from fumes given off by such chemicals as Formaldehyde, Coal-Gas, Mercurous compounds, Paints, Peroxide, Ammonia and Turpentine, remembering also that, in the case of exposed films stored near Sulphurous gases, a change in the Silver Halide may take place and will give rise to Silver Sulphide thereby causing the image to turn brown.

Abstracts From Current Literature

Hirschsprung's Disease.—The Radiologist frequently sees cases of dilatation of the colon. By careful examination he can definitely differentiate Hirschsprung's disease from Idiopathic megacolon. Hirschsprung first reported this condition in 1888, though numerous articles on megacolon appeared prior to this. He described two cases with constipation, and meteorism without any evidence of stenosis of the colon. He attributed the cause of dilatation of the colon to a congenital defect and since the time of his report his name has been attached to the type of congenital dilatation of colon which occurred in children. Recent investigations have produced evidence that the dilatation of colon is not congenital but develops weeks or months after birth and megacolon is classified as a dysfunction of evacuation of unknown origin. A disturbance of autonomic innervation of the colon is considered as probable cause. In 1948 Swenson and Bill reported that roentgenological examination reveals a "spastic" segment of colon distal to the dilated part and they concluded on clinical grounds that this obstructive narrowing is responsible for the dilatation. More recently Bodian *et al* have by means of X-ray investigation been able to differentiate two types of megacolon. (i) Idiopathic, and (ii) Hirschsprung's disease. In the chronic stage of Hirschsprung's disease the plain film of the abdomen may show gross gaseous distention with flaring of ribs and distended colon below the diaphragm on both sides. With the Barium Enema the rectum appears to be normal or less than normal size; above the rectum the diameter of the colon narrows for a short distance which varies from case to case. Above this narrowed portion the colon opens by a wide funnel into a hugely dilated, gas filled colon. Once this dilated portion is filled the narrowing below may be

obscured and difficult to demonstrate. This narrowed segment of colon in the rectosigmoid area gives the clue in the differential diagnosis between Hirschsprung's disease and Idiopathic megacolon. The Idiopathic megacolon is of two types; in one the distention is confined to the rectum and the distal pelvic colon, forming a terminal reservoir; in the second group there is a tubular dilatation which extends from the anal orifice throughout the colon. The barium enema in the first group reveals that the rectum and the distal pelvic colon form a pear shaped unilocular dilated chamber extending in some cases from the anus to the xiphisternum. In the second group the rectum appears quite large and the pelvic colon is much longer and wider and lacks its normal haustral markings, but the contours of the bowel is otherwise normal. The boundary between the normal and the abnormal bowel in this type is ill-defined. The cause of Hirschsprung's disease is said to be due to complete aplasia of para-sympathetic ganglion cells in the autonomic plexuses of the distal segment. It has been found that in Hirschsprung's disease rectosigmoidectomy gave gratifying results.

The barium enema technique consists of the following: (i) no routine preparation is undertaken; (ii) to avoid sequelae of dehydrated barium in the colon glycerine and paraffin were introduced into barium emulsion. This was run into the bowel from a initial height of three feet above the table through a soft rubber catheter introduced to a minimum distance into the rectum. The flow was under the immediate control of the Radiologist and the initial filling of the rectum and the rectosigmoid is closely observed. The flow of the enema is stopped as soon as the diagnosis is made and pictures taken. X-rays are also taken immediately after evacuation.—Abstract from Editorial in *American Journal of Roentgenology and Radium Therapy*, February, 1949.

Hydrothorax in Congestive Heart Failure.—For a long time there has been an impression that the right hydrothorax is much more frequent than the left, in congestive heart failure. McPeak and Levine have established from an analysis of a series of cases that this is a fact. They group their cases under three general headings: (1) Those exhibiting hydrothorax in congestive heart failure as revealed by clinical signs and paracentesis thoracis; (2) those exhibiting hydrothorax as shown in X-ray examination; (3) those cases of congestive heart failure which exhibit hydrothorax at postmortem examination. They have come to the conclusion that from whatever angle an analysis is attempted, the factors which determine transudation of fluid into the pleural sacs, exert influence in such a manner as predominantly to involve the right pleura. This is more so in the rheumatic heart conditions as compared to those in which failure of the left heart is more frequent. Numerous attempts have been made to explain this frequency of right hydrothorax in congestive heart failures. The following are the views expressed by various workers from the early times.

1. The earliest theory is that of Baccelli (1867). He advanced the azygos theory assuming that the pleural fluid accumulated through disturbance in the systemic circulation; for a long time his views were accepted without question.

2. The later views explained this frequency of the right hydrothorax as due to the effect of pressure on the root of the right lung and the azygos vein by an enlarged right auricle.

3. The third view is that transudation of fluid into the pleural sacs takes place from the visceral pleura rather than from the parietal and therefore depends upon the involvement of the pulmonary instead of the systemic circulation. The pressure on the right or left pulmonary vein by a dilated right or left auricle determines the location of the pleural fluid and since the right auricle is more commonly dilated than the left, the frequency of the right hydrothorax is common.

4. Experimental data demonstrating that the pressure negativity in the right pleural sac is greater than that in the left in the normal individuals was a hypothesis to explain the tendency for the preponderance of right hydrothorax. The assumption of the right lateral decubital position taken up by cardiac patients is said also to favour the occurrence of right hydrothorax.

5. Alterations in the permeability of lung capillaries is said to play an important role in the pulmonary exudations. Two factors pulmonary pressure and anoxia, are fundamental in causing transudation into the lungs and pleural sacs.

McPeak and Levine accept the view that the visceral pleura is the principal source of the hydrothorax; they also accept the view that pulmonary capillaries are particularly susceptible to certain forces promoting transudation. They say there are yet a number of anatomical and physiological factors which have got to be considered in this connection. Among these are (1) the right lung is some 10 per cent greater in volume than the left; (2) there is a disproportion between the areas of visceral pleura on the two sides of the chest; (3) any factor which tends to limit respiratory excursion such as hypostasis, hepatic engorgement, cardiac enlargement etc tears down the natural defences against the consequences of local increased capillary transudation.

It has been shown that the pulmonary lymphatic drainage takes place almost entirely through the right lymphatic duct with limited anastomosis to the thoracic duct. Mr. McPeak and Levine question as to what effect this might have on the lungs individually when lymphatic stasis occurs and whether left lung receives greater benefit from collateral drainage. They also refer to the roles played by visceral and parietal pleurae in the absorption of fluid; but there is little work done in this field to base an opinion.

They conclude that none of the theories are wholly adequate or satisfactory. Further research and investigation is needed.—Abstract from the Editorials, *The American Journal of Roentgenology and Radium Therapy*, September, 1948.

Announcement

PRESIDENTIAL ELECTION

Drs. K. M. Rai, S. C. Sen, and R. F. Sethna were duly nominated by several members of the Association. Drs. K. M. Rai and R. F. Sethna having withdrawn in favour of Dr. Sen, it gives me great pleasure to announce that **Dr. S. C. Sen** has been unanimously elected as the **President** of the Indian Radiological Association for the year 1950 and the Fourth Indian Congress of Radiology.

Yours sincerely,

M. N. DASANNA,

General Secretary.

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