RADIO-ACTIVE COBALT BOMBS AND SUPER-VOLTAGE RADIOTHERAPY FOR SOUTH AFRICA

MAURICE WEINBREN, B.Sc., M.R.C.S., L.R.C.P., F.F.R., D.M.R.E.

Johannesburg

The publicity given to the unfortunate child with the osteogenic sarcoma who was sent overseas by public subscription has naturally raised the question in the lay press why radio-active cobalt bombs and super-voltage radiotherapy are not available in South Africa.

In the first place, it ought to be realized that there is nothing specific about the radio-active cobalt rays. For the purpose of cancer treatment their wave lengths are equivalent to those of the 2½-million-volt X-ray machine or, for that matter, of the super-voltage machines ranging up to 8 million volts or more. Radio-active cobalt is not taken up by osteogenic sarcomata or other cancers in the manner radio-active iodine is taken up by the thyroid, and does not cure osteogenic sarcomata.

It is stated by Sir Stanford Cade that a few cases who had been irradiated either with the radium bomb or the 2-million-volt machine survived longer than the average. There is no specific difference in the effect of the wave lengths from the radium bomb, the radio-active cobalt bomb and the 2-million-volt machine. Sir Stanford Cade has had long experience of the treatment of these osteogenic sarcomata and, after the installation of the 2-million-volt machine at the Westminster Hospital in 1951, he started to treat a group of cases with it. As one would expect, these cases have been very carefully documented and followed up. In his latest paper on the subject, published only a few months ago (Cade S. 1955)[1] Sir Stanford Cade pointed out that 80% of the cases die within 2 years irrespective of the method of treatment, 91% within 3 years, and 96% within 4 years; and that only 4% have lived longer than 4 years, dying in the 5th and 19th year. Only 2 out of 85 cases treated between 1925 and 1950 with teleradium have survived (16 and 30 years respectively). Of the other 10 who survived over 6 years, 8 had some form of surgery also.

DIFFICULTIES IN SOUTH AFRICA

I do not propose to discuss the treatment of osteogenic sarcoma here, but to draw attention to the difficulties in installing large radio-active cobalt bombs or super-voltage therapy in South Africa. There are bombs of the 60-curie type at several British hospitals, but there is only one large 1,000-curie bomb. It is of the rotating type and is installed at the Mount Vernon Hospital, London. It was presented to Sir Stanford Cade and Professor Windeyer by a philanthropic Canadian for the British Empire Cancer Campaign and was installed at the end of 1953.[5] This is the first bomb of its kind in Europe.

There are certain inherent difficulties in the installation of radio-active cobalt bombs or super-voltage apparatus such as the 2-million-volt electrostatic generator or the linear accelerators of the 4-8 million volt range. Some of the difficulties are common to all these types of apparatus:

Heavy Expense

A radio-active cobalt unit of the Mount Vernon type would cost somewhere in the region of £25,000 to £30,000 when installed in South Africa. There are smaller radio-active cobalt bombs of the 60-curie range at several English hospitals, but as Sir Stanford Cade's name has been mentioned in relation to this particular case, presumably the agitation for an installation in South Africa refers to the Mount Vernon type. The X-ray plants such as the 2-million-volt electrostatic unit which is made in the United States, or the linear accelerators which are made in Great Britain also cost in the region of £30,000 now. (Before devaluation, the 2-million-volt unit in Boston cost £18,000.)

It is not generally known, and in justice to the late Mr. A. S. Hersov it ought to be mentioned, that, in 1947, he authorized me to buy a 2-million-volt unit for use in Johannesburg. The order was actually placed through the Anglo-Transvaal offices in New York with the High Voltage Engineering Corporation in Boston, an option being taken for 3 months pending investigation whether suitable premises and staff could be found to operate the unit. Neither suitable premises nor the necessary staff could be obtained, and so the order was cancelled.

The *housing*, i.e. the buildings required, with sufficient protection and the accessory offices to run a unit of this description, would cost more than the unit itself.

The *running costs* of these units is very high. In the cobalt unit there is the difficulty of replacing the radio-active cobalt at intervals of, say, 3-4 years. The half-life of cobalt is 5·3 years, and therefore the radio-active cobalt has to be re-activated, or a new supply of it obtained, every 3-4 years. Now radio-active cobalt in large quantities up to 1,000 curies may take over a year to activate in the atomic pile and cannot just be sent over without adequate protection.[6] It would be necessary to send from overseas a complete new head containing the cobalt, which would have to be exchanged for the old head. This is by no means a simple matter. I observed the 60-curie cobalt unit being installed at University College Hospital, London, and it required a considerable staff of engineers to do it. The cost of operating these cobalt or super-voltage units does not consist of the actual wear and tear of the moving parts only, but includes the salaries and maintenance of engineers and physicists. A single physicist could not keep a linear accelerator functioning, or even a radio-active cobalt unit.

Expert Staff

This brings us to the greatest difficulty of all, and that is the expert staff required to keep one of these units operating and to work out the physical data and determine the doses which are delivered by these units at certain depths under certain conditions for each patient. To operate the unit without such skilled staff exposes the patient and the staff to great danger.

In Great Britain some of the larger hospitals actually employ more physicists than radiotherapists in their departments. The Cancer Hospital, the Middlesex Hospital and other hospitals in London have at least as many physicists as radiotherapists. Even with these large numbers of physicists at the hospitals and the manufacturers close at hand, it is no simple matter to keep these units functioning. The fact that so many physicists are required makes it impossible to work out exactly the cost of operating one of these machines. The physicists are not on one job all the time. There is research work to be done, and when there is a breakdown they are all needed in the repairing and calibrating of the machine. It took some 6 months to erect and calibrate the radio-active cobalt unit at the Mount Vernon Hospital, where a group of physicists are employed.

South Africa missed being the first country outside the United States to have a 2-million volt machine because we could not get the staff together from here or abroad to operate the machine. This difficulty still exists in South Africa and, in fact, it has become worse because in the interval South Africa has lost more expert physicists than it has gained. With the opening of the atomic plants in England and America, the opportunities abroad for research work and appointments are much greater than in South Africa. The C.S.I.R. for instance, has lost 3 physicists who were in charge of the isotope work; in the last 3-4 years 2 of them have found posts in Great Britain and one in Canada. I drew attention to this aspect of the matter at the Medical Congress in Pretoria in 1948.[2] This difficulty of getting skilled staff is universal, and exists in the United States and in Great Britain; but it is much greater here. Some of the hospitals and private radiologists in South Africa have tried for years to get physicists and have failed to do so.

Because of the lack of facilities both in skilled engineers and equipment, it has not, for instance, proved possible to check the output of an ordinary high-voltage X-ray diagnostic unit in terms of milliamps and kilovoltages. None of the firms selling X-ray equipment, and not even the Bureau of Standards, have the facilities for checking the claims of manufacturers concerning the capacity of their X-ray apparatus.

How under these conditions could one expect to erect and maintain radio-active cobalt bombs and super-voltage X-ray therapy apparatus? The people who give press interviews and advice that this unit should be installed at one place and that the Cancer Association should put up units at other places, are obviously not conversant with inherent difficulties. Besides, radio-active cobalt is not so plentiful that a unit can be obtained immediately by merely ordering one. As I have said, it takes over a year to activate the cobalt in a pile of a certain strength. The question still remains, what should we gain at present even if all these difficulties were overcome and one or more units were installed in South Africa?

THE LIMITATIONS OF RADIOTHERAPY

The profession and the public may have been misled by the publicity in the lay press. The term 'cobalt bomb' sounds very powerful and effective. It immediately brings to mind the terrific power of H bombs and uranium bombs. The cobalt bomb would therefore, in the mind of the public, have the power to disrupt and destroy all cancers. This, unfortunately, is very far from the truth, whether one is dealing with the radio-active cobalt bomb or the much more powerful X-ray generators of the linear accelator type which go up to 8 million and 12 million volts and higher. Attention has repeatedly been drawn to the fact that, as a primary radical form of cancer therapy, radiation is disappointing.[3,4]

It is only in certain accessible sites and with certain radio-sensitive tumours that radiotherapy plays a part in the sense of successful radical treatment.[7] It plays a much greater part in palliative treatment, but the public think in terms of cures and not of palliation. What, for instance, can radiation do, no matter whether it is 200 KV or 20 million KV, for cancer of the alimentary tract, excluding limited cancers of the oesophagus? No radiation will cure cancer of the stomach or cancer of the colon or rectum. The only method of curing these cancers is by surgery. What can radiation do in the sense of a radical cure in carcinoma of the lung? Here, too, the only chance of a cure is an operation at a very early stage. What can radiation do in cancers of the genito-urinary system? Cancers of the kidney, when operable, have to be removed; so do cancers of the ureters. Cancer of the bladder does respond under certain conditions to local radiation-therapy with radium: it does not require super-voltage therapy for the radical treatment. Moreover, Ralston Paterson, in answer to a question during his recent visit here, admitted that with super-voltage therapy at Manchester he has observed more rectal reactions than formerly when treating carcinomas of the bladder. Cancer of the brain and the spinal cord when operable have, with very few exceptions, to be treated by surgery and not by radiation.

Cancer of the skin does not require super-voltage therapy. It would be completely out of place for epitheliomata and rodent ulcers. Incidentally, it does not matter how high the voltage, how big the machine, a melanoma will not be cured by radiation, with the exception of a very few radio-sensitive melanomas—and these will respond to conventional radiotherapy. It is only in accessible cancers such as those of the skin, the mouth, the tongue, the larynx and the pharynx that radiation therapy plays a radical role. While it is true that super-voltage therapy under suitable conditions with suitable staff makes the treatment easier and less trying for the patient, it does not hold out any great promise of cures in regions where conventional therapy does not cure. Its main application at present is again in the field of palliative therapy. Here it plays its greatest role.

It must be remembered that 1-million-volt therapy has been practised at Barts for 20 years, and quite a number of 1-million-volt therapy units have been in operation in the United States for many years, and no great superiority from the radical-cure point of view has been demonstrated with these units over the conventional 200-250 KV unit. It must also be remembered that the difference in biological efficiency between the units of 1-2 million volts and the conventional radiotherapy at 250 KV is greater than that between the 8-million-volt unit and the 2-million-volt unit; so that no very startling results can be anticipated theoretically even from the 8-million-volt accelerators.[8]

Cancer of the skeletal system such as osteogenic sarcoma is not cured by radiotherapy even though out of 85 cases Sir Stanford Cade has had 2 cases which have survived 16 and 30 years, and 10 cases 6 years and over, mostly with combined radiation and surgery.

CHOICE OF SUPER-VOLTAGE UNIT

Finally, if South Africa is to get a super-voltage unit, what type is it to be? Are we to get a radio-active cobalt unit, a 2-million-volt X-ray machine, a linear accelerator of the 8-million-volt type, a betatron of the 20-million type, a synchrotron of higher voltages still, or the newer isotope-bombs which are being developed such as the Cesium of 33 years half-life.

Nobody can answer these questions. If it could be answered—if the superiority of one type over the others had been demonstrated,— the large hospitals in Great Britain would not have a multiplicity of types. The Royal Marsden Hospital (Cancer Hospital) in London, for instance, besides various types of rotation therapy of the 250 KV range, has a betatron, a 4-million-volt linear accelerator, a 2-million-volt X-ray machine and a radio-active cobalt bomb of 1,000 curies. The Middlesex Hospital, which is associated with the Mount Vernon Hospital, Radiotherapy Department, has a 10-gram radium bomb. At the Postgraduate Hospital and Barts, linear accelerators have been installed. In Manchester, a linear accelerator and a betatron of the 20-million-volt type were installed at the same time in 1953. In Edinburgh, Professor McWhirter dispensed with his 10-gramme radium bomb, and instead has installed in the new Cancer Centre a rotating type of 250 KV X-ray therapy and a linear accelerator.

It is right and proper that these large institutions with all the facilities of finance and staff should have this variety of apparatus for research work. Very few clinical reports have been published so far because some years must elapse before any results can be demonstrated, and most of the journals dealing with this subject publish articles on the physics of super-voltage therapy and not the clinical aspect. The first 5 articles in the latest British Journal of Radiology (April 1956) are devoted to the physical factors and not to the clinical results of super-voltage therapy and radio-active cobalt therapy. The best type of super-voltage unit or bomb unit from the clinical aspects has not yet been demonstrated. As we have neither the financial facilities nor the personnel, what would be the use of installing super-voltage radiation apparatus in South Africa at present? If and when the superiority as far as cures are concerned of one type of super-voltage therapy over the others is demonstrated, then the financial obstacles will fall away, for obviously if these machines will cure cancer, the money will have to be found. The only difficulty remaining then will be that of personnel—the greatest difficulty of all, and one which will not be easily overcome.

PRACTICAL PROPOSALS

In spite of the clamour for super-voltage therapy, it is suggested that greater facilities for X-ray therapy of the conventional type, i.e., up to 250 KV, should be provided. The expense of providing these units is not great, and radiotherapists can use these machines (unless they are of the rotating type) without the constant attendance of physicists. The rotating-type machine, even of only 250 KV, does require the constant collaboration of skilled physicists. The use of such machines where the help of physicists is not constantly available, is a source of danger to the patient; I have seen some disastrous results in various parts of the world from the use of these machines even when physicists were available. The risk to the patient and staff with super-voltage machines is still greater if they are not properly staffed.

The place of radiotherapy in the treatment of malignant disease and benign conditions, with the standard 200-250 KV, is well established. Nevertheless, hospitals exist, and are at present being built, in populous areas without X-ray therapy facilities; yet it would be a simple matter to staff X-ray therapy departments in these hospitals with radiotherapists who are in private practice in the neighbourhood.

Radiotherapy should be brought to the patient as far as it is reasonably possible where the size of population makes it feasible and reasonably economical, and not the patient made to travel every day long distances to X-ray departments. Many patients avoid X-ray treatment because of these difficulties.

In combined treatment, i.e. surgery and radiotherapy, as for instance in carcinoma of the breast, the more important part of the treatment is the surgery. Surgeons visit and operate at hospitals other than the main hospitals, and yet when it comes to, X-ray therapy there is no provision there and the patient is compelled to travel sometimes many miles backwards and forwards daily for perhaps 6 weeks for X-ray treatment. The result is that many patients either attend irregularly or do not attend at all. If skilled surgery can be done at local hospitals, why cannot radiotherapy be done at the same hospitals, provided it is economically possible?

REFERENCES

1. Cade, S. (1955): J. Roy. Coll. Surg. Edinb., **1**, 79.
2. Weinbren, M. (1949): S. Afr. Med. J., **23**, 566 and 600.
3. Weinbren, M., Henning, A. J. and Cones D. M. T. (1955): Medical Proceedings, **1**, 28.
4. *Idem* (1955): Ibid., **1**, 193.
5. Jones, D. E. A., Gregory, C. and Birchall, I. (1956): Brit. J. Radiol., **29**, 196.
6. Lanzie, L. H., Davison, D. B. and Raine, W. J. (1955): Amer. J. Roentgenol. **74**, 898.
7. Weinbren, M., Cones, D. M. T. and Henning, A. J. H. (1955): Medical Proceedings, **1**, 116.
8. Morrison, R., Newbery, G. R. and Deeley, T. J. (1956): Brit. J. Radiol., **29**, 177.