SUPERVOLTAGE RADIOTHERAPY

LIONEL COHEN, M.B., B.CH. (RAND), D.M.R.T. (R.C.P. & S., ENG.)

Johannesburg

A recent paper on *Radio-active Cobalt Bombs and Supervoltage Radiotherapy for South Africa*[1] deals with a subject of vital importance in the treatment of cancer in this country. The undeniable fact that many patients, not excluding doctors, go overseas for treatment, suggests that we are not all satisfied with the standards of radiotherapy now available here. The ideas expressed in this paper are, in fact, at variance with almost all enlightened opinion throughout the world. At the recent conference in Geneva on the peaceful applications of atomic energy, the widespread acceptance of telecurie units for routine radiotherapy, and their many advantages over conventional methods, was emphasized. Indeed, scores of such units have now been mass-produced, and are operating with gratifying success in the USA, the USSR, Canada, South America, Eastern and Western Europe, Australia, India, China and Britain. Is South Africa to be a unique exception?

This form of treatment is opposed on the ground that South Africa, in contradistinction to all other countries in the civilized world, cannot cope with the extraordinary physical and economic difficulties entailed. This may seem to be the case from the point of view of private radiotherapeutic practice, but it should not be so in relation to the very different problems presented by organization and resources in the large Provincial hospital centres. Yet these advanced techniques have, apparently, no place in the type of radiotherapy which, with a few notable exceptions, is currently practised in this country, and which is generally characterized by systematic underdosage.[2]

These considerations confirm the writer's previously expressed view[2] that the highest standards of radiotherapeutic practice can be supplied only in fully equipped, centrally organized, regional institutions. In such institutions, the use of supervoltage radiation presents no insuperable difficulties, physical or economic, and leads to a definite improvement in the results of treatment, not only in that certain patients who would not have responded to conventional radiotherapy can be cured, but also in that a large proportion of patients curable by conventional radiotherapy would be spared many of the unpleasant reactions and complications unavoidable with conventional radiotherapy. It is obvious, therefore, that there is need to consider these recent developments from the point of view of the current and future requirements of the Provincial hospitals.

CLINICAL CONSIDERATIONS

While palliative treatment is still an important, though diminishing, part of radiotherapeutic practice, it is in the effort to increase the proportion of permanent cures that the development of the new techniques and equipment is being pursued.[3] It has been shown,[4] that the curability of the larger and less accessible tumours is limited by the feasibility of delivering large doses to the tumour relative to that received by overlying skin (heterogeneity factor), and by the relative tolerance to radiation of the tumour and the host (therapeutic ratio). Both these factors improve progressively as the energy or exciting voltage of the beam is increased, and reach a theoretical optimum in the 4-million-volt range. With this quality of radiation deep-seated tumours can be treated radically with little or no visible skin-reactions and no risk of

necrosis; systemic reactions are milder, minimizing the nausea, vomiting, diarrhoea and leucopenia which so often prevents completion of a pre-calculated course of treatment; and there is less differential absorption of bone and cartilage, eliminating the complications of chondronecrosis and osteitis in the treatment of tumours of the mouth, head and neck, breast and pelvis. In fact with any tumour extending more than 5 cm. below the skin, and in any situation where bone or cartilage is traversed by the beam, i.e., in about half of all tumours seen in South African hospitals, supervoltage therapy has very material advantages. In fact the improvement is much greater than published figures show, since cancer statistics based on 5-year and 10-year cure rates always lag behind the best results being achieved.

It may be predicted, therefore, that with the exception of non-malignant conditions, skin lesions and the radiosensitive sarcomas, all radiotherapy will, in the very near future, be conducted with megavoltage and telecurie equipment. Such developments in cancer therapy inevitably demand large regional centres fully staffed and equipped to handle the new techniques.

Under conditions currently prevailing in Johannesburg, for example, it is estimated that the most efficient service, from both clinical and economic considerations, would be given by *two* supervoltage units: one, a 4 MeV linear accelerator, primarily for high-output and large depth-dose treatment to deep-seated tumours, but also adaptable to cases in the other category; and the second, a 1,000-curie unit using cobalt-60 in the first instance for high-quality irradiation of the bony and cartilaginous regions of the head and neck, but adaptable as an alternative to the accelerator if required. The relatively low-dosage output of the telecurie unit is compensated for by the continuous activity of the source, so that by the organizing of 8-hour shifts the normal working turn-over of patients can be tripled without any additional strain on the equipment. The two units, though each ideally suited for specific depth and quality problems, would thus be interchangeable if required should one be out of action for repairs or adjustments.

TECHNICAL AND ECONOMIC ASPECTS

Objections raised on account of expense, housing, staffing, running costs, and physical peculiarities of the materials, have all been overcome overseas, and could easily be solved in the larger Provincial hospitals of this country. In South Africa about 10,000 new cancer-cases requiring therapy occur each year, and each of the 6 existing major radiotherapy centres copes with from 1,000 to 1,500 cases annually, of which about one-half would benefit from supervoltage irradiation. The *initial cost* to each centre of two units totalling, with all the ancillary building and equipment, well under £100,000, can hardly be considered an excessive investment for the treatment of 500 human beings annually, especially as it would be offset by a considerable saving in treatment time and hospitalization expenses. The *housing* of a supervoltage unit entails concrete walls, floors and roofing up to 1 metre in thickness, obviously prohibitive in a city block of offices, but a simple architectural problem in any central institution designed for the purpose. By suitable siting of a single-story treatment-wing, using outer walls abutting on an unoccupied space or garden, the housing of such units costs no more than that of any conventional X-ray set.

Running costs of telecurie units are negligible apart from replacement of decayed isotope at intervals. Since only part of the source need be re-activated at any one time, a very small fraction of the reactor facility with modern high-neutron-flux piles need be occupied for this purpose, at a correspondingly low cost. In the near future cobalt-60 sources would be replaced with caesium-137, a by-product of uranium fission produced in embarrassingly large quantities by all atomic power plants, which will probably be given free to hospitals and industry to avoid expensive alternative methods of disposal. The long half-life of 33 years makes replacement rarely necessary. These units are fool-proof and require no skilled staff other than radiographers.

With megavoltage generators, at least with the efficient linear accelerators, the high radiation output and rapid turn-over of patients are such that, in a large institution, the running costs are actually lower than that of the several conventional therapy machines that would be required to cope with the same number of cases. Employment of a maintenance engineer may be advisable, but his salary, too, would be offset by the lower running costs of the more efficient units.

Staffing a radiotherapeutic physics-department has become a universal problem owing to the demands of industry on the supply of skilled physicists. South Africa is somewhat better off in this respect than most other countries, since the industrial demands have not yet developed greatly. The successful construction and operation of the cyclotron, a far more complicated instrument than any radiotherapy generator, by a locally-trained staff in Pretoria, shows that this country does not lack physical skills. Because of the greater simplicity in beam-direction and dosimetry, supervoltage radiation actually requires less computational work on the part of the physics staff than the detailed isodose-planning necessary if conventional radiotherapy is to reach comparable efficiency.

It must be remembered that physicists are not required to operate and maintain the radiation generators; their function lies in the planning and execution of specific treatment-policies developed in consultation with the radiotherapist. With this end in view, 3 of the Provincial radiotherapy-centres have already appointed their physics staffs, and these departments will serve as nuclei for training hospital physicists in this country. When the time comes to install the new units, there will be no lack of skilled physicists in our hospitals, and indeed some Provincial centres have already made advanced plans for expansion, including the supervoltage units described.

ORGANIZATION OF A REGIONAL CENTRE

We have shown that the optimal treatment of cancer, taking advantage of modern developments in therapy, requires the development of large regional centres in which the expensive and complicated equipment can be housed, and the large clinical and ancillary staff can be concentrated. To meet the requirements of this country 6 regional centres are needed, but with its more widely dispersed communities it is necessary to compromise between the advantages of a highly centralized organization like the Holt Radium Institute in Manchester, and the difficulties in transporting country patients to centres in the large cities. One solution suited to the mixed urban, suburban and rural, multi-racial communities of South Africa, embodies a regional centre based on existing facilities and organized at 3 levels:

1. *The Central Unit*, housing the administrative head and his offices; the senior radiotherapists, physicists, engineers, radiographers, workshop technicians, clerks, radium custodian and librarian; the radium and isotope store; physics and biology laboratories; records and statistics files; teaching facilities; protection service; and major special equipment, including the 2 supervoltage units described above.

2. *Two Hospital Sub-centres*, European and non-European, each with conventional high-voltage and superficial therapy machines, wards, theatres, out-patient facilities, and departmental staffing for radical radiotherapy of potentially curable cases.

3. *Several Peripheral Clinics*, under the direct control of the sub-centre, strategically sited in populous suburban or rural areas, each having one inexpensive versatile medium-voltage therapy machine and one radiographer, with a radiotherapist sent from the centre for one or more weekly sessions to see new and follow-up cases and to prescribe treatment for those non-malignant conditions and simple palliative procedures which do not require the facilities and technical precision available at the larger hospitals.

Since many hospitals would be encompassed in a single regional scheme, it would be advisable for the Centre to be under direct Provincial control rather than under several hospital boards, although existing hospital radiotherapy facilities would have to be taken over.

That these proposals are workable is shown by the success of a similar organization in Australia, where the population distribution resembles ours. By an Act of the State Parliament of Victoria, a Cancer Institute has been established with a Central Unit at Melbourne and Radiotherapy Sub-centres at several surrounding hospitals. After exhaustive discussion among administrators, radiotherapists and physicists, somewhat along the line indicated here, the Institute has purchased from Metropolitan-Vickers, Ltd., a 4 MeV linear accelerator installed at a total cost of £65,000!

It is an interesting comparison to note that these developments in Australia were brought about through the activities of the 'Cancer Institute Board', a constitutional body whose general aims resemble those of our National Cancer Association but who, unlike our Association, have undertaken to develop all

the necessary facilities for the efficient treatment of cancer in a State institution, to establish centralized radiotherapy units, and to support research directed to these ends, before embarking upon cancer education drives, detection centres, and 'fundamental' research. The officers of our Association might do well to note this logical order of development in cancer services, and the necessarily close liaison between this Board and the State administration; they might perhaps consider emulating this example by establishing a similar liaison with our Provincial administrations and appointing Provincial-hospital radiotherapists, surgeons and pathologists to their committees.

SUMMARY AND CONCLUSIONS

The future of cancer therapy is South Africa lies with centralized regional institutions, each based on a population of 2-3 millions and treating up to 2,000 new cases a year.

About half of these cases would benefit materially from supervoltage radiation, most conveniently generated by telecurie isotope units or linear accelerators, either or both being installed in each centre according to the turn-over of patients.

In such large centres the supervoltage units virtually pay for themselves on account of their larger output and simpler operating techniques, compared to the several conventional machines that would otherwise be needed to handle the same turn-over.

The National Cancer Association should work in close liaison with the Provincial hospital services and give active support to the provision of radiotherapy projects on the most modern lines. Such activity by the Association would be worthy of the generous public support it has received.

REFERENCES

1. Weinbren, M. (1956): S. Afr. Med. J., **30,** 520.
2. Cohen, L. (1954): *Ibid.*, **28,** 1124.
3. Paterson, R. (1955): *Ibid.*, **29,** 1215.
4. Cohen, L. (1951): Brit. J. Cancer, **5,** 180.