BRITISH PRACTICE IN RADIOTHERAPY

SIR ERNEST ROCK CARLING
B.W. WINDEYER
AND
D.W.S MITHERS

BUTTERWORTHS
MEDICAL
PUBLICATIONS

BRITISH PRACTICE IN
RADIOTHERAPY

Under the General Editorship of

SIR ERNEST ROCK CARLING
LL.D., F.R.C.S., F.R.C.P., F.F.R.
CONSULTING SURGEON, WESTMINSTER HOSPITAL; CHAIRMAN, INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION

B. W. WINDEYER
M.B., B.S., D.Sc., F.R.C.S., F.R.A.C.S., F.F.R.
PROFESSOR OF RADIOLOGY, UNIVERSITY OF LONDON; DIRECTOR, MEYERSTEIN INSTITUTE OF RADIOTHERAPY, MIDDLESEX HOSPITAL; CONSULTANT IN RADIOTHERAPY TO THE ROYAL AIR FORCE

and

D. W. SMITHERS
M.D., F.R.C.P., F.F.R.
PROFESSOR OF RADIOTHERAPY, UNIVERSITY OF LONDON; DIRECTOR, RADIOTHERAPY DEPARTMENT, ROYAL CANCER HOSPITAL; CONSULTANT IN RADIOTHERAPY TO THE ROYAL NAVY

LONDON
BUTTERWORTH & CO. (PUBLISHERS) LTD.
1955

BRITISH PRACTICE IN
RADIOTHERAPY

AFRICA: BUTTERWORTH & CO. (AFRICA) LTD.
DURBAN : 33/35 BEACH GROVE

AUSTRALIA: BUTTERWORTH & CO. (AUSTRALIA) LTD.
SYDNEY : 8 O'CONNELL STREET
MELBOURNE : 430 BOURKE STREET
BRISBANE : 240 QUEEN STREET

CANADA: BUTTERWORTH & CO. (CANADA) LTD.
TORONTO : 1367 DANFORTH AVENUE

NEW ZEALAND: BUTTERWORTH & CO. (AUSTRALIA) LTD.
WELLINGTON : 49/51 BALLANCE STREET
AUCKLAND : 35 HIGH STREET

Printed in Great Britain by R. J. Acford Ltd., Chichester, Sussex

INTRODUCTION

This book is designed to present a picture of radiotherapy practice in Great Britain today. Between so many contributors there must be differences of opinion, but the presentation is probably more representative of the thought and practice among radiologists than might have been attained by a single author. Although the work is complete in itself it is also a companion volume to *British Surgical Practice*.

An outstanding feature of British practice in radiotherapy in recent years has been the growing co-operation between radiotherapists and their surgical and medical colleagues. A real attempt is being made to reach full appreciation of what each has to offer our patients. To emphasize this development the editors suggested that each contributor should ask one of his other clinical colleagues to collaborate with him.

We planned the form of this volume, told our contributors what we wished to achieve and asked them to present a general view of British practice rather than to express too vehemently their individual preferences. While accepting responsibility for what appears here on general lines, we have tried not to interfere too much with each person's view, thinking it more important to select the right contributor than to find ourselves in complete agreement with everything written.

Specialization, although a necessity, has many disadvantages. When a specialty requires a great deal of expensive apparatus and much technical assistance, when moreover it is organized into treatment centres, it becomes increasingly difficult to avoid the dangers inherent in fixing its boundaries and making its practice exclusive. When to these difficulties are added the problems inherent in the handling of potentially dangerous radio-active materials and high-voltage apparatus which must be controlled by strict codes of practice, unusual care is necessary to ensure a healthy development. Radiotherapy, even more than most specialties, requires the freest possible interchange of ideas and the closest practical collaboration with others working in associated fields. The progress of radiotherapy may well depend as much on the success with which it preserves some elasticity of organization and deliberately avoids its tendency to isolation as upon the construction of more powerful apparatus or the introduction of new treatment methods.

British radiotherapy has made great strides in the last 20 years and much of this has been due to an increase in precision in dose measurement, in plotting dose distribution, and in the accuracy of application of the treatment planned. This phase of development was notable for the introduction of precision methods into radium treatment by Paterson and his colleagues in Manchester and by the fundamental work on measurement and of three-dimensional dose distribution, together with the concept of integral dose, introduced by Mayneord and his colleagues in London. Parallel steps towards a better understanding of the fundamental biological effects of radiation were being taken at the same time in Great Britain, chiefly by Spear and Lee in Cambridge and by Gray in London. These developments have led to a degree of accuracy in clinical work which has made possible a real attempt at radiobiological research at the point where it is most needed, in the complicated organization of the living tissues of the patients

themselves. Radiobiological research departments are now attached to several radiotherapy centres and are becoming an important part of their work. The day when it will be as natural to consult with a radiobiologist about the radiation treatment of patients as it is to consult with a physicist may not be far distant. The necessity to appreciate the technical complications of radiotherapy and to master the physics upon which it is based has been a hindrance to more general appreciation of its function by medical men as a whole. Advance in radiobiology may well be one of the most useful means of overcoming the danger of isolation, which, largely for its lack, has hung over the specialty of radiotherapy from the first.

This book deals with some of these general problems in its preliminary articles and later goes into the details of individual treatments required by patients with different diseases at different sites. It is mainly concerned with malignant disease, but the use of radiotherapy in non-malignant conditions is dealt with in the light of the concepts which have been slowly developing since the days of its widespread and indiscriminate use.

We are grateful to our contributors for responding so well to our requests and for complaining so little about the restrictions of space and form of presentation we had to impose upon them.

E. ROCK CARLING
B. W. WINDEYER
D. W. SMITHERS

CONTENTS

PART I

GENERAL PROBLEMS IN RADIOTHERAPY

DOSAGE AND MEASUREMENTS

DEVELOPMENT OF DOSIMETRY IN RADIOTHERAPY

By W. V. MAYNEORD, D.Sc., F.Inst.P.

Professor of Physics applied to Medicine, University of London ; Physicist to the Royal Cancer Hospital, London

INTRODUCTION

Physical science during the last 25 years has contributed greatly to the progress of Medical Radiology, and it is therefore important to review the present situation as seen from the point of view of that science. It is not true, as is sometimes supposed, that there was at the beginning of that period relatively little physical inquiry ; indeed, there was probably as much relative effort on the physics side as now. The difference which strikes one is rather the generality of the concepts which now guide the therapeutic applications and the wide range of technical facilities now available. The change of emphasis has been from the technology of the equipment to the general conceptions of dosimetry and radiobiology, now of such fundamental importance. In the early days there were in essence two main physical problems to be solved. First the production of radiation of the right " quality ", which resolved itself into the quest for higher and higher quantum energy, and secondly the development of a generalized system of dosimetry which could be used over the whole field of ionizing radiation. With respect to the first of these two problems, for many years the principal question was the ratio of the dose which could be delivered at a depth in the tissues compared to that at the surface. The skin, happening to be particularly sensitive, limited the amount of radiation which could be delivered at a depth and the most ingenious geometrical devices were required to obviate the difficulty. Nowadays there is a resurgence of the " rotation " therapeutic techniques, which certainly have great advantages and do make this ratio of dose at the depth to dose at the surface very high. The present techniques are possibly capable of still greater generalization but this is not the place to discuss them.

From the use of radiations produced at 50–60 kV., perhaps with little or no filtration, we have gradually changed first to the 200 kV. region then to the half million, then the one to two million region, and finally to the region of 20 Mev. in which some radiation therapy is now being carried out. In the process a great deal has been learnt about the fundamental physics of radiation and its interaction, especially with light elements, and the concept of " dose " has grown clearer particularly in respect of relative significance of the electromagnetic radiation at a point and the " dose " at the point, that is the energy taken from secondary corpuscular radiations near a given point in tissues. In the early days the ranges of the secondary particles biologically effective were so small that no essential distinction needed to be made, but this situation no longer holds. This distinction forms the basis of the difficulties of measuring radiation of high quantum energy. The difficulties are in no real sense technical, but rather matters of clear thinking as to the precise quantity which we wish to specify, define and measure. This duality may become even more important at still higher excitation voltages, for

the radio-activity produced in the tissues is directly the result of the action of gamma-quanta whereas the dose as now defined is a measure of the action of secondary electrons or other particles having quite different interaction with atomic nuclei.

Distribution of radiation

The two sets of problems relating to the distribution of radiation in tissues and technical methods of producing the radiation have become merged into one. Looking ahead it is by no means certain that much, if any, advantage is to be gained by seeking still higher voltages than those now available for x-ray production. For example, although electron accelerators exist capable of producing equivalent voltages of the order of 300 Mev., the angular width of the electromagnetic beam is so reduced at these high voltages that the beams would be relatively inconvenient for therapeutic purposes. It may well be that at least for some time the main region of therapeutic usefulness will remain at the 1–10 Mev. level, though the higher energies will always retain their research fascination and should be explored. In a sense the urge to the production of more and more penetrating radiations has lapsed, not because we cannot produce radiations with more penetration of tissues (though partially this is true owing to the appearance of pair-formation at very high voltages) but because the other properties of the radiation produced at very high energies are such as to make their satisfactory therapeutic use inconvenient. There is also the very serious economic factor. The cost of particle accelerators rises very rapidly with energy and correspondingly the cost of treatment of a substantial fraction of cases of cancer occurring each year might be prohibitive, quite apart from the difficulties of production of machines and their relatively low efficiency judged in terms of the time they can be relied upon to run under therapeutic conditions.

Dosimetry and nomenclature

In the search for higher and higher energy radiations we have been forced to consider again the problems of dosimetry and nomenclature. On the practical side this has meant that organizations have had to be built up capable of dealing with the day-to-day problems of dosimetry as distinct from their rather more serene experimental and academic aspects. In this country the tendency has increasingly been to rely on highly trained radiographers and to develop methods of solving the complex geometrical problems by simple mechanical or optical means. We could certainly now claim a great deal of experience in the methods of arranging beams of x-rays so as to produce concentrations of energy of the extent and level which are necessary, but so far little useful theoretical generalization seems to be possible in relation to these problems; certainly, so far, no generalized system of multiple beam dosimetry seems to have been evolved. After many years of attempting to obtain a homogeneous distribution of x-radiation at a high level throughout the tumour with the relative sparing of normal surrounding tissues there seems nowadays to be some tendency to swing to an attempt at the production of heterogeneity, at least in types of tumours not successfully treated by the first method. The ideal of " controlled heterogeneity " is still with us.

The first major development in dosimetry in the last quarter of a century was probably the attempt to extend the system of dosimetry based upon the röntgen as unit of dose already in use for x-rays, to gamma-rays, particularly the gamma-rays from radium. At first it was freely predicted that this extension was not