MEDICAL PHYSICS: THE AGENCY'S CONTRIBUTION

Twenty years ago very few people in the world had heard of "medical physics". Even today a medical physicist is comparatively rare and in many countries does not exist at all. But what is medical physics? A brief answer is "physics applied to medicine", but this does not carry us much further. These two branches of learning have completely different traditions. Until quite recently, medicine was essentially an art rather than a science; it is only in the present century that the methods of the natural sciences have been applied to medicine on an appreciable scale. Physics, on the other hand, has always been one of the exact sciences, a science of measurement, through which we study the mechanical, electrical, optical and other properties of matter. However, for hundreds of years physics and medicine have been interrelated by the personal interests of a few outstanding individuals. For example, the foundations of the science of magnetism were laid by a physician, William Gilbert (1544-1603). The tradition of co-operation is therefore well established. What is new to this century, even to the post-war years, is the employment of professional physicists in hospitals and medical institutes.

The scope of physics in medicine is truly enormous. Many functions of the body, from the circulation of the blood to the action of a muscle, obey physical laws and may usefully be studied by the physicist. Even the common stethoscope is essentially a physical instrument. However, the branch of medicine in which physics has made its greatest impact is radiotherapy. The first physicists to hold hospital appointments worked in this field, and even today the great majority of medical physicists are engaged in radiation work. Furthermore, when a new post is created for a physicist in a hospital, particularly in the developing countries, it is almost certain to be related to radiotherapy. In many countries, medical physics means simply "radiotherapy physics" and it is because of this close association with radiation that the Agency has developed a strong interest in the field.

Physics Applied to Radiotherapy

Physics and radiotherapy are natural partners. The doctor who employs penetrating radiation for the treatment of cancer is using a powerful tool which obeys both physical and biological laws. Comparatively little is known as yet on the biological effects of radiation, but the physical aspects have been intensively studied and it is accepted that, for many purposes relevant to his treatment, the patient is equivalent to a block of inert material such as a tank of water. The dose of radiation delivered to each part of a patient can be determined by the physicist through measurements in a so-called "water phantom". Thus the physicist can make an important contribution to the treatment of the cancer patient.

Until recently most radiotherapy throughout the world was carried out by means of X-ray machines which emitted radiation of comparatively low energy and limited penetrating power. This radiation obeyed the laws of physics just as the more penetrating radiation used today, but it had the further property of producing a marked skin reaction (similar to a severe sunburn) which acted as a warning to the doctor to stop the treatment before a harmful amount of radiation was delivered. In the last ten years, however, there has been a gradual switch to sources of radiation known as "isotopic teletherapy units", which contain radioactive isotopes such as cobalt-60 and to X-ray machines in the so-called supervoltage range. This change-over was discussed in some detail in an earlier article in this Bulletin (Volume 4, No. 1, January 1962, page 23) and is continuing today at an accelerated pace. The rays emitted by cobalt-60 units and supervoltage machine are much more penetrating than ordinary X-rays and are, therefore, able to treat deep-seated tumours more effectively. Furthermore, owing to an effect known as "build-up", the dose of radiation increases for a certain distance below the surface, instead of decreasing steadily as in the case of ordinary X-rays, and the skin reaction is, therefore, small or even non-existent. This, of course, is an advantage in that the patient is spared the discomfort and pain of a burnt skin, but at the same time the radiotherapist has lost his warning signal. In the absence of a skin reaction it is only too easy to give an excess dose of radiation which can permanently damage underlying structures such as muscle. The only safeguard is to control the amount of radiation given to the patient strictly according to the measurements and calculations of a radiation physicist. That is why the physicist is assuming today a more important role in radiotherapy than ever before.

Activities of the Agency

It is clear that the Agency cannot promote the application of radioisotopes in therapy without, at the same time, encouraging the employment of physicists in this field. This encouragement takes three forms. Firstly, the Agency supplies information as to the advantages of employing physicists in radiotherapy institutes and general guidance as to their qualifications, training, duties and responsibilities. Secondly, training in radiation physics is provided for suitable candidates and assistance given in establishing physics services in individual hospitals. Finally, even when

An expert panel meeting held by IAEA in Vienna, November 1960, on dose distributions for high-energy radiation. Left to right: Madame Andrée Dutreix (France), Dr. J.R. Cunningham (Canada), Dr. M. Cohen (UK, now a member of IAEA Secretariat), Dr. E. Casnati (Italy), Dr. Sven Benner (Sweden), and Dr. G. Adams (USA)

a physicist is trained and established in a hospital he may require a good deal of support in the form of data which he cannot obtain for himself, advice, and general contact with the outside world. These forms of assistance will be briefly described.

(a) Information on physics in radiotherapy: One of the most useful means of disseminating information on the role of physics in radiotherapy has been found to be the recommendations of a group of experts of acknowledged international repute. Such a group was convened in Montreal in September 1962 by the Agency and the World Health Organization. The group comprised 18 radiotherapists and physicists from 13 countries, and met under the chairmanship of Professor Sir Brin Windeyer of the Meyerstein Institute of Radiotherapy, Middlesex Hospital, London. The meeting was organized as a follow-up to an earlier one (also jointly sponsored) which took place in Vienna in 1959 and the report of which was published in several languages in radiological journals and also as part of an Agency booklet ("The Use of Radioisotopes and Supervoltage Radiation in Radioteletherapy" 1960).

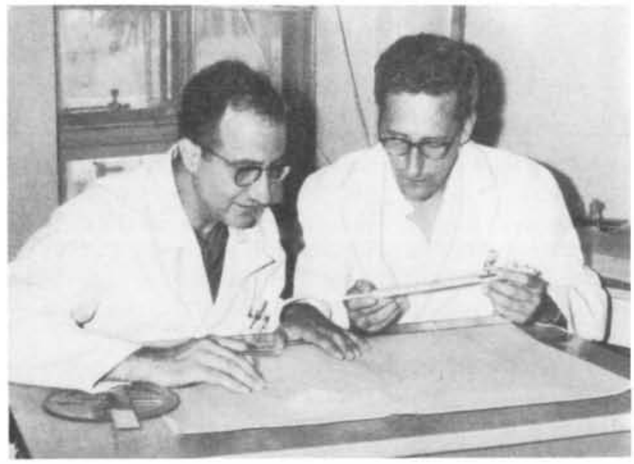
The recommendations of the Montreal group have recently been published in radiological journals in English, French and Spanish under the title "Practical Methods of Assisting Radiotherapy Centres in Less-developed Areas", and it is expected that publication in other languages will follow. The recommendations contain detailed suggestions as to the establishment of radiotherapy centres, the responsibilities and duties of radiotherapy personnel (including radiotherapists, physicists and technicians), and training and assistance. Emphasis is placed on the need for the full-time employment of physicists in radiotherapy institutes.

Recommendations such as those just mentioned are, of course, of a general nature. Suggestions of a more local kind are made by experts assigned by the Agency to individual countries or institutes, as indicated below.

(b) Training and assistance: Up to the present, fellowships to enable physicists to be trained abroad in radiotherapy have been awarded to seven individuals. The period of training has ranged from one month to two years. In addition, fifteen physicists from different parts of the world are participating in the Agency's first Advanced Training Course on the Physics of Radiotherapy, which has just begun in London (September 1963). These scientists have all had a certain amount of experience and are working in hospitals, but lack training in the use of cobalt units and other sources of high energy radiation. The course will run for five months and has been organized in co-operation with the Hospital Physicists' Association (HPA). Lectures will be given by a group of British radiation physicists, and each student will receive practical training in two hospitals or radiotherapy institutes, one in the London area and the other in the provinces.

Another important form of assistance is the establishment of the post of Regional Adviser in Physics Applied to Radiotherapy for countries of the Eastern Mediterranean. This post was recommended by a special advisory mission on teletherapy which visited the region early in 1962 on behalf of the Agency. The work of the mission was greatly facilitated by the participation of the World Health Organization's Regional Adviser in Radiotherapy, Dr. P. Taillard. The first Agency Adviser, Mr. T.H. Bryant of the Middlesex Hospital Medical School, London, took up his duties in April 1963. Mr. Bryant has his headquarters in Beirut, Lebanon, and at the time of writing has visited Cyprus, Greece, Iran, Iraq, Syria and Turkey. Visits to other countries in the region will

At the American University Hospital, Beirut, the IAEA Regional Adviser on the physics of radiotherapy, Mr. T.H. Bryant (right), and the hospital radiotherapist, Dr. Philippe Isso, carrying out depth dose calculations



Also at the Beirut hospital, Mr. Bryant instructing a technician (Miss Shake Kodjian) on how to carry out radiation measurements on a cobalt unit

follow. In each country Mr. Bryant advises the Government and individual institutes on the establishment or development of physics services in radiotherapy, trains local scientists in radiation physics and initiates a programme of radiation measurements appropriate to the local conditions. A further important aspect of the Adviser's duties is the creation of conditions for collaboration between the physicists in the various radiotherapy institutes participating in the project. The assignment will be continued for a further year (as from October 1963) by Professor J. E. Roberts, also of the Middlesex Hospital Medical School, and it is hoped that the project will later be extended into 1965 or 1966.

The Regional Adviser project is conceived as a long-term form of assistance covering a number of countries in a defined geographical area. In addition, experts in radiation physics are sent to individual countries for shorter periods (up to one year) but for essentially the same purpose. Until recently these assignments were combined with duties in other fields (e. g. health physics or nuclear medicine) but nowadays the trend is to assign an expert solely for the physics of radiotherapy and at present such posts have been approved for Ceylon and Thailand. Posts in several other countries are under consideration.

(c) Provision of data: The supply of information and data is a service which the Agency renders for all medical physicists, whatever their country or experience, but naturally the newly established physicist in a developing country needs more help in this respect than his colleagues from advanced institutes. The Agency has already brought out a number of publications in radiation physics and allied fields, and only two recent additions will be mentioned here. The first of these (Technical Report Series No. 8) gives details of over 2600 "isodose" charts for high energy radiation so that the radiation physicist can select those he needs for his work and obtain copies through the facilities of the Agency. This is the first step in the setting up of an international "clearing house" which the Agency proposes for radiation physics data.

The second publication is also concerned with isodose charts, this time in the form of an atlas of "Isodose Charts and Tables for Medium Energy X-rays" which was published by Butterworths (London) under Agency sponsorship. The work was carried out by Agency staff members in collaboration with Temple University, Philadelphia, USA, and the Hospital Physicists' Association, United Kingdom. The atlas contains a set of 250 self-consistent charts, with associated numerical data and explanatory material, and is by far the largest collection of its kind in existence. Three further atlases in similar format are now in the final stages of preparation. These will be for high energy radiation, including the gamma-radiation from cobalt and caesium teletherapy units. The three atlases will be for single fields, multiple fields and moving beams respectively, and it is hoped that they will be available early in 1964.

Hitherto the Agency has been concerned mainly with "teletherapy", i. e. treatment by powerful sources of radiation located at some distance from the patient, but it is now proposed to provide data and other assistance in the fields of "interstitial, intravacitary and surface" therapy, in which smaller sources of radiation are used on or inside the patient. An international panel of experts in these fields is to meet in Vienna in November 1963 to discuss the problems involved.

Co-operation with Other Organizations

It will be clear from this account that close collaboration with the World Health Organization has been established so that the help which both organizations provide in medical physics can be co-ordinated and improved.

The Agency also maintains good relationship with a number of other bodies working in the radiological field. Among these may be mentioned the International Commission on Radiological Units and Measurements (ICRU), the international organization which is concerned primarily with the physical aspects of radiotherapy. Besides contributing to the scientific work of the Commission, the Agency has, for the past two years, made a direct financial contribution to ICRU. In April 1961, an advisory panel on clinical dosimetry was convened jointly by ICRU, WHO and the Agency. It should also be mentioned that the Agency is undertaking the translation and publication in other languages of the ICRU reports, hitherto available only in English.

The Hospital Physicists' Association, mentioned earlier, is the oldest and biggest of the associations of physicists who are engaged in medical work (not necessarily, of course, in radiotherapy). The HPA was formed in 1943 and now has about 560 members, including about 140 from outside the United Kingdom. In more recent years similar organizations have been formed in many other parts of the world, notably in Australia, Canada, the Netherlands, Scandinavia, and the USA. The Agency has close and cordial relations with many of these associations, as well as with numerous individual medical physicists. An International Organization for Medical Physics, linking the various national associations, was inaugurated at the beginning of this year.

NEW MATERIALS IN NUCLEAR TECHNOLOGY

A major objective of current research in nuclear technology is to develop reactor materials that can withstand the effects of high temperature and intense radiations. The efficiency of a nuclear power station - more specifically, the efficiency of utilizing the heat for the production of electricity - is partly dependent on the temperature at which the reactor can be operated, but the working temperature cannot be increased to the point at which the fuel elements will fail.

This has led to a search for non-metallic forms of nuclear fuel, because in general these have a higher melting point than metallic fuels. Oxides of uranium, of course, have been used as reactor fuel from the earliest days of nuclear technology, but considerable work is still being done to improve the production and fabrication of oxide fuels so that they may be able to stand up to the progressively exacting conditions to which they may be subjected in a reactor. Simultaneously, work is being carried on to develop other forms of non-metallic fuel, such as carbides, nitrides and silicides, as well as new materials for use as reactor components other than fuel.

The IAEA Director General, Dr. Sigvard Eklund (middle), addressing the opening session of the Prague conference. Others on the podium, left to right: Mr. Joseph C. Delaney (IAEA); Mr. Witold Lisowski (IAEA); Dr. Karel Petrzelka, Resident Representative of the CSR to IAEA; Dr. Jan Neumann, Chairman of the CSR Atomic Energy Commission; Dr. Jaroslav Kozesnik, Vice-President of the CSR Academy of Sciences; Dr. Adolf Svoboda, Mayor of Prague; Dr. Čestmir Simane (IAEA); and Mr. Alexander Pushkov (IAEA)

A conference on New Nuclear Materials Technology, held in Prague last July by the International Atomic Energy Agency, showed that this work is likely to improve considerably the performance of nuclear power stations and thus contribute to a reduction in power costs. Hopeful references to this possibility were made both by the Agency's Director General, Dr. Sigvard Eklund, in his opening address to the conference, and by Dr. Cestmir Simane, Director of the Agency's Division of Technical Supplies, in a speech at the closing session.

Dr. Eklund said that recent experience with nuclear power stations had shown that the working temperatures, burn-ups, load factors and lifetimes of the plants were greater than anticipated and this had given rise to cautious optimism about the future of nuclear power. In the established reactor types, however, temperature limitations of the fuels or of the cladding materials imposed a limitation on operating temperatures and net plant efficiencies. For example, in Magnox cladding (as in the natural uranium power reactors operating in Britain) the steam temperature was limited to 400°C, and the net plant efficiency in both Magnox reactors and the light water reactors fuelled by enriched uranium was about 30 per cent. Uranium oxide fuel with stainless steel cladding, on the other hand, would permit steam temperatures of about 480°C. With uranium carbide fuel dispersed in graphite one could a tain a steam temperature of 540°C, which would give a net station efficiency of about 35 per cent.