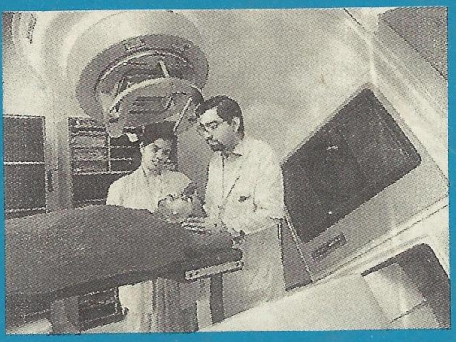
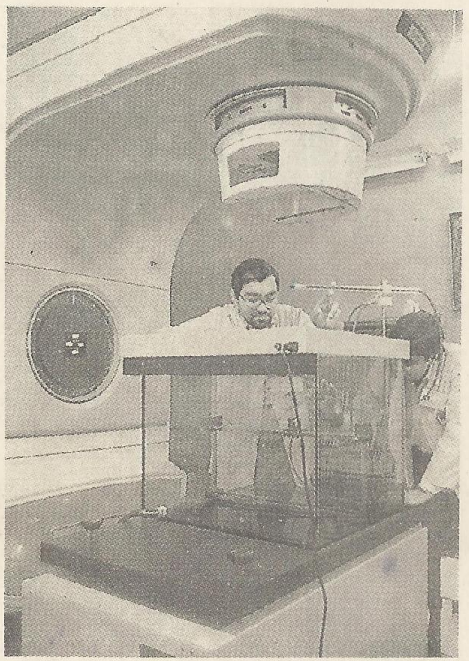
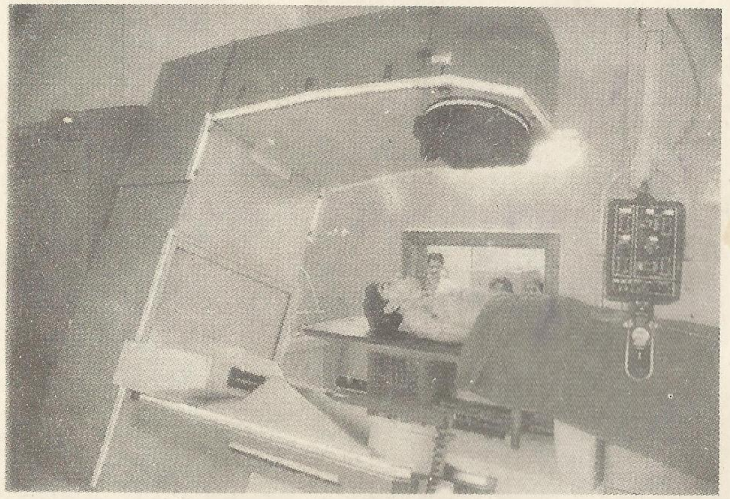
AMPI



SCOPE AND RESPONSIBILITIES OF MEDICAL PHYSICISTS IN INDIA



Beam data acquisition using water phantom is an important step in treatment planning.

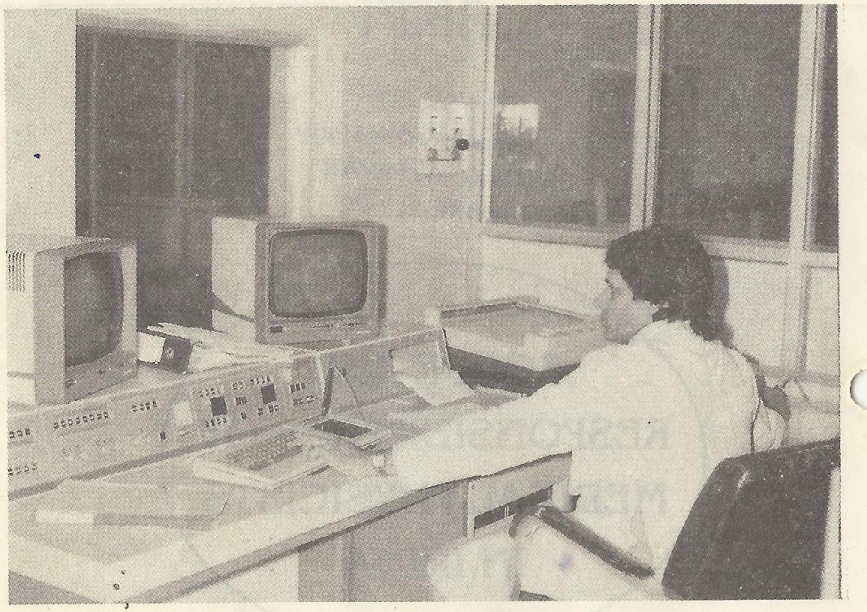


For accurate treatment it is necessary to confirm the treatment parameter using a simulator

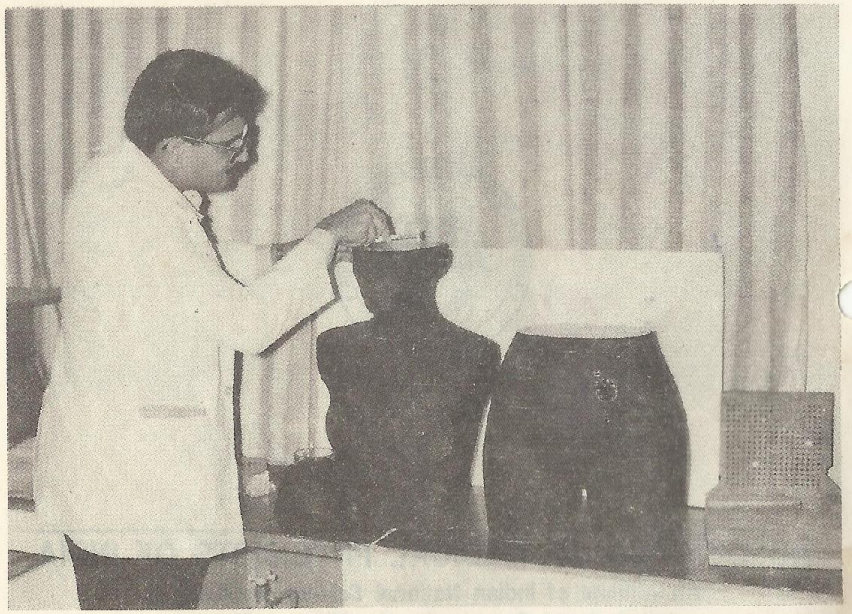
AMPI

SCOPE AND RESPONSIBILITIES OF MEDICAL PHYSICISTS IN INDIA

ASSOCIATION OF MEDICAL PHYSICISTS OF INDIA
An Affiliate of Indian National Science Academy &
International Organization for Medical Physics



Radiation treatment requires careful planning for each patient using computers



Various types of anatomical phantoms are used to determine dose distribution in patients.

AMPI

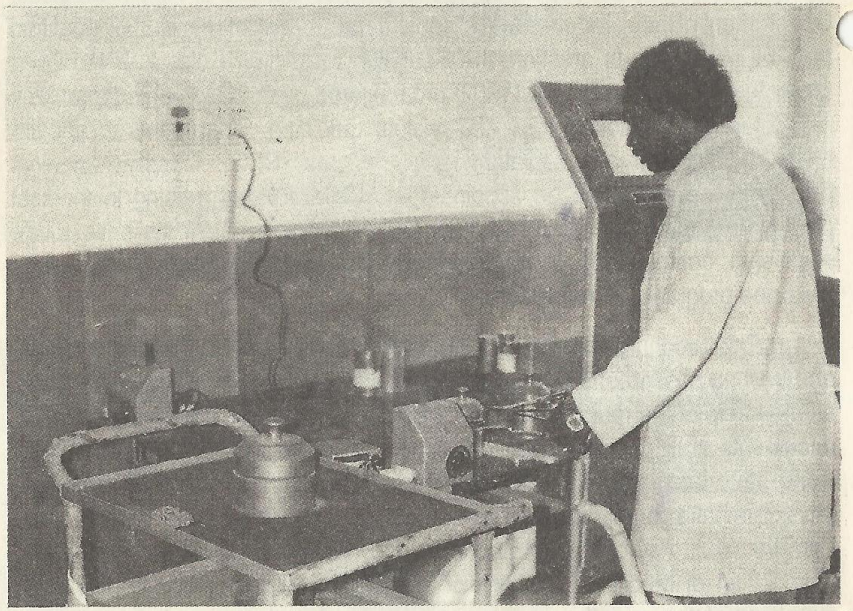
Preface

A medical physicist is an important member of the health care team in a radiotherapy department. The Standing Committee on Radiotherapy Development Program appointed by the Director General of Health Services, Government of India, requires that all radiotherapy departments employ qualified medical physicists. In addition, the Radiation Protection Rules (1971) issued under the Atomic Energy Act (1962) promulgated by the Govt. of India make it mandatory for all radiotherapy and nuclear medicine departments to appoint medical physicists and radiation safety officers (RSO). Qualified medical physicists are eligible to be appointed as RSOs. Formal training in medical physics in India started in 1962. Since then, medical physicists have made significant contributions to the development of radiotherapy and nuclear medicine programs in the country.

This brochure has been prepared to focus attention on the educational and training background of medical physicists, their scope and responsibilities as members of the radiotherapy team and the regulatory requirements. Similar documents from professional organisations of medical physicists around the world have been consulted in preparing this brochure. A number of medical physicists have contributed significantly in bringing up this brochure to this level. I am thankful to all of them. I am happy to present this as a document of the Association of Medical Physicists of India and hope this will help the other members of the radiotherapy department and health care administration in appreciating the role of medical physicists amongst them

(M.S.S. Murthy)
Secretary, AMPI

Bombay,
24 April 1995.



In manual after-loading brachytherapy great care is required to design and prepare the applicators.

AMPI

What is Medical Physics

It has always been man's endeavour to diagnose and treat human diseases as precisely as possible. In this effort he has learnt to effectively employ the tools, techniques and principles of physical sciences. Invention of microscope to study the microorganisms which cause various types of human diseases, the stethoscope to transfer sound from the beating heart to the ears of the physician, use of the period of a pendulum to investigate the irregularities in the pulse rate of a patient, thermal expansion of mercury to measure body temperature are some of the early examples. Developments in electromagnetism in the 19th century lead to the therapeutic applications of high frequency electric current and development of various types of electric measuring instruments which are the forerunners of today's highly sophisticated electrocardiography and electro-encephelography equipment and a host of other equipment in various branches of medicine such as neurology, ophthalmology, nephrology, etc.

The discovery of X-rays by Wilhem Conrad Roentgen in 1895, the phenomenon of radioactivity by Henry Becquerel in 1896 and radium by Mary Curie in 1898 rapidly advanced the application of ionising radiations to diagnosis and treatment of diseases. In the later part of the 20th century elucidation of the structure of DNA using techniques of X-ray crystallography and genetics by physicists, James Watson and Francis Crick and the subsequent application of physical principles for sequencing and analysing DNA molecules opened up the possibility of correcting inherited defects by genetic engineering. Developments in lasers have lead to *insitu* destruction of cancer cells and bloodless surgery. Progress in electronics and computer technology have enabled physicians to make diagnosis and treatment of diseases more precise and accurate. Today's modern medical department is not just a store house of various coloured liquids and powders but a complex system of machines and instruments flashing coloured lights, beeping information, displaying images, charts and contours. It is staffed with physicians, physicists and technologists. Table I shows some important branches of medicine which have greatly benefited by the application of physics.

Responsibilities of Medical Physicists in India
Prepared & Published by Radiological Physics Division,
Babha Atomic Research Center, Bombay – 400 085.
Ph: 022 – 2556 3060 Ext: 2201

AMPI

Table I : Some major areas of medicine benefited by Physics

General medicine	Instrumentation; application of radioactive isotopes for dilution analysis, metabolic investigations, functional tests such as radioimmunoassay (RIA) absorption studies, circulation studies, localization of tumours.
Anaesthetics	Application of the physics of gases and aerosols in studies connected with respiratory system.
Cardiology	Electrocardiography, echocardiography, ballistocardiography, muscle stimulation, blood pressure and flow investigations.
Dermatology	Treatment of skin diseases by radiation, skin colour measurement.
Neurology and Neurosurgery	Brain tumour detection by radiation, magnetic resonance imaging (MRI) and ultrasound (US); electrical and electronic techniques, to study nerve transmission network.
Obstetrics and Gynaecology	Radioisotope tracer investigations and US techniques for studies on fetal developments, tumour detection etc. radiation treatment of cancer.
Ophthalmology and Otology	Diagnosis and treatment of defects in vision; contribution to the theory of hearing, assessment and treatment of deafness; noise control.
Pathology, Physical medicine, Radiology and Radiotherapy	Microscopy; short wave and microwave treatment; electrical stimulators; telemetry; Imaging of internal organs; determination of mineral content of bone; radiotherapy of cancer.
Surgery	Bio-mechanical devices; tumour localisation by CT, US, MRI techniques; laser applications; lithotripsy.

Responsibilities of Medical Physicists in India
Prepared & Published by Radiological Physics Division,
Babha Atomic Research Center, Bombay – 400 085.
Ph: 022 – 2556 3060 Ext. 2201

AMPI

Thus medical physics is a discipline concerned with (a) application of physical concepts and methods to the understanding of human body in health and disease, (b) the introduction of new and more precise techniques into the investigation and treatment of the individual patient, and (c) ensuring the availability and use of resources of physics in day-to-day medical practice.

In retrospect, the discoveries of X-rays and radium in the last decade of the 19th century were the two most important events which brought physicists directly to the hospital environment. Roentgen himself realised the potential of his discovery as an aid to visualise the internal structures of human body. Within weeks of his discovery, X-rays were used in a hospital in Vienna to help in setting a broken arm. Today, modern radiology has evolved into a highly sophisticated and amazingly sharp imaging system with the use of image intensifiers, computed tomography, digital subtraction techniques, etc. Historically, X-rays arrived in India during the first decade of this century and today there are more than 50,000 X-ray units in radiological services, with nearly a thousand new machines added every year.

Similarly, Mary Curie's discovery of radium firmly established the use of ionising radiations and the role of physicists in cancer therapy. The advent of nuclear reactors and particle accelerators in the mid 20th century brought out a host of powerful and flexible radiation sources such as ^{60}Co, ^{137}Cs, ^{192}Ir, ^{99m}Tc on the one hand, and linear accelerators, microtrons and cyclotrons, on the other, for cancer treatment. This also made available a number of man-made radioisotopes, creating a whole new branch of medicine called nuclear medicine (or radiation medicine). Tools such as gamma camera, positron emission tomography (PET), single photon emission computed tomography (SPECT), and more recently nuclear magnetic resonance imaging (MRI) and spectroscopy (MRS) have further enhanced the diagnostic capabilities.

In India, presently, there are about 208 teletherapy units and 114 brachytherapy systems in 107 cancer therapy centers and 119 nuclear medicine departments in the country. In addition to this, a number of laboratories carry out *invitro* investigations in human health using ionising radiations.

Responsibilities of Medical Physicists in India
Prepared & Published by Radiological Physics Division
Babha Atomic Research Center, Bombay – 400 085.
Ph: 022 – 2556 3060 Ext: 2201

Regulatory Requirements in the Appointment of Medical Physicists

The wide-spread use of ionising radiations in medicine and other areas has brought in its wake the need for exercising regulatory controls to ensure safety of the patients, users and general public. For this purpose, the Government of India promulgated the Atomic Energy Act (1962), issued Radiation Protection Rules (1971) and constituted the Atomic Energy Regulatory Board (1983). The Chairman, Atomic Energy Regulatory Board (AERB) is the competent authority to develop and implement appropriate regulatory measures to ensure safety in use of ionising radiations. According to the AERB safety codes (SC / MED-1, SC / MED-3 and SC / MED-4) it is mandatory for all radiotherapy and nuclear medicine departments to employ medical physicists and radiation safety officers (RSOs). In addition to this, the Standing Committee on Radiotherapy Development Program appointed by the Director General of Health Services, Government of India, also insists on the appointment of qualified medical physicists in each radiotherapy department. Similarly, AERB safety code SC / MED-2 requires the appointment of qualified RSOs in all diagnostic radiology departments. In some major cancer centres medical physics service is organised as an independent department, whereas in others it is integrated into the corresponding clinical departments.

Responsibilities of Medical Physicist

In the radiological field (external beam therapy, brachytherapy, X-ray diagnosis and nuclear medicine), medical physicist has the following responsibilities.

(i) Equipment selection, maintenance and installation planning

(ii) Calibration and quality assurance

(iii) Treatment planning

(iv) Education and training

(v) Research and development

(vi) Radiation safety

Responsibilities of Medical Physicists in India
Prepared & Published by Radiological Physics Division,
Babha Atomic Research Center, Bombay – 400 085.
Ph: 022 – 2556 3060 Ext: 2201

Equipment Selection, Maintenance and Installation Planning

(a) Advise the hospital administration on the detailed specifications of new equipment and their performance characterisation before purchasing, so that standard and type approved equipment are procured.

(b) Establish a liaison with manufacturers (suppliers) to ensure timely servicing, repair, and maintenance. This also implies that appropriate standards of electrical and mechanical safety of the equipment are maintained.

(c) Take necessary steps for decommissioning of aged equipment at appropriate time.

(d) Plan new installations (or modify existing ones where necessary) from regulatory point of view, keeping in mind ease of patient movement, technologist's comfort, radiation safety and operational and emergency requirements.

(e) Maintain an inventory of all radiation sources.

(f) Supervise source transfer operations of telegamma and brachytherapy units.

Calibration and Quality Assurance

(a) Conduct acceptance tests and evaluate the performance of new equipment to ensure that they satisfy the required specifications.

(b) Calibrate all radioactivity and dose measuring instruments and dosimeters and ensure their traceability to national standards, where applicable.

(c) Measure specific activities and radioactivity concentrations of radio-pharmaceuticals used in nuclear medicine.

(d) Establish and operate approved quality assurance program for all the equipment and procedures.

Responsibilities of Medical Physicists in India
Prepared & Published by Radiological Physics Division,
Babha Atomic Research Center, Bombay – 400 085.
Ph: 022 – 2556 3060 Ext: 2201

AMPI

Treatment Planning

(a) Determination of the physical characteristics of treatment procedures – these include type of radiation, energy of radiation and dose output in the case of beam therapy; generation of necessary radiological data, preparation of sources, source trains or wires for manual or remote controlled units in the case of brachytherapy.

(b) Provide a treatment plan after the radiotherapist has given in writing the target volume, tumour dose and specifications of implant (in case of brachytherapy). The plan should include field size, field direction, duration of treatment, dose distribution in tumour and normal tissues.

(c) Ensure, in consultation with the radiotherapist, the safety and accuracy of devices such as applicators, implants etc. used in brachytherapy.

(d) Carry out patient dosimetry, whenever required by using suitable dosimeters, to verify the dose delivered.

Education and Training

Provide education and training in medical physics including radiological safety, to physicians, nurses, technologists, engineers as well as trainee physicists.

Research and Development

(a) Carry out research and development of new techniques, equipment, and methodologies for continued improvement in diagnostic and therapeutic capabilities and safety of patients.

(b) From time to time, carry out intercomparison of dosimetry systems with national and international organisations. Evaluate entrance and exist doses to the patients and carry out dosimetry in phantoms simulating newer treatment techniques.

Responsibilities of Medical Physicists in India
Prepared & Published by Radiological Physics Division,
Babha Atomic Research Center, Bombay – 400 085.
Ph: 022 – 2556 3060 Ext: 2201

AMPI

Radiation Safety

The medical physicist has all along played an important role in the implementation of the radiological protection program of the hospital. In many large hospitals one medical physicist may be specially designated as the Radiological Safety Officer (RSO) responsible for radiation safety. The duties and responsibilities of the RSO have been set out in the Radiation Protection Rules (1971). Hence they will not be elaborated here (see Annexure I). Eventhough the final responsibility for radiation safety lies with the licensee, every medical physicist has the responsibility to ensure safety of patients, workers and general public in the use of radiation sources under his / her control with the active support of the hospital administration.

It must be remembered that a medical physicist is member of a team dedicated to the health care of the patient. Hence, utmost cooperation between him and the therapist and technologist is essential to achieve this goal. However, medical physicists will not be directly responsible for the following activities :

(a) To examine / admit / nurse the patients.

(b) For tumour localisation, radiation dose prescription, tissue complications during or after radiation treatment.

(c) To administer radioisotopes (either in the form of a pharmaceutical in nuclear medicine or in the form of discrete sources in brachytherapy) to the patients.

(d) To remove the radiation sources from the patient at the termination of brachytherapy treatment.

(e) For patient setup during routine radiotherapy, though he may guide the technologist on the first day of treatment of each patient.

(f) For repair of radiation equipment, though he may attend to some minor repair work.

(g) For the biocompatibility of radiopharmaceuticals and materials used in accessories such as tubings, templates and applicators.

Responsibilities of Medical Physicists in India
Prepared & Published by Radiological Physics Division,
Babha Atomic Research Center, Bombay – 400 085.
Ph: 022 – 2556 3060 Ext: 2201

AMPI

Medical Physics Staff Requirement

In western countries, the physics support in a radiological department is given by persons in various cadres such as physicist, junior physicist, dosimetrist, health physicist, and quality assurance technologist. (This does not include radiotherapy technologists). However, in India, these various cadres are generally not available. Keeping this in mind, and based on the recommendations of WHO, it may be suggested that for every 200-250 new patients treated per year one additional physicist should be appointed. Acquisition of additional equipment such as linear accelerators, cobalt units and remote afterloading systems will require further strengthening of physics staff.

Education and Training Opportunities for Medical Physicists in India

Two major institutions in India conduct training courses in medical physics. The Radiological Physics Division (formerly the Division of Radiological Protection) of Bhabha Atomic Research Centre, Bombay has been a pioneer in this field. It has been conducting, since 1962, a one year post-graduate diploma course in Radiological Physics. The diploma is given by the University of Bombay. The minimum qualification to enter this programme is a second class M.Sc. degree in Physics (from the academic year 1994-95) from a recognised university. The course contents include the physical properties of ionising radiations, their diagnostic and therapeutic applications, treatment planning, quality assurance, dosimetric instrumentation, radiation safety and regulatory aspects, and supporting areas such as statistics, computer applications, anatomy, physiology and radiation biology. In addition, the curriculum contains a number of laboratory experiments, one-month practical training in the various departments of the Division and a two-month apprenticeship in major cancer therapy centres in the country. A similar programme was offered by the Saha Institute of Nuclear Physics at Calcutta in collaboration with Cancer Centre and Welfare Home, Thakurpukur.

Anna University in Madras offers a two year M.Sc. programme in Medical Physics in collaboration with the Cancer Institute, Madras. This programme covers, in addition to radiological physics as mentioned above, other areas of medical physics such as ultrasonics, lasers and biomedical instrumentation. A few universities also offer Ph.D. degree for advanced thesis work related to medical physics.

Responsibilities of Medical Physicists in India
Prepared & Published by Radiological Physics Division,
Babha Atomic Research Center, Bombay – 400 085.
Ph: 022 – 2556 3060 Ext: 2201

AMPI

Status of Medical Physicists in India

A medical physicist is a member of a team of specialists responsible for diagnosis and treatment of patients. By virtue of his special training, a medical physicist has competence in certain areas, essential for patient care, which are not found among other medical or paramedical staff. Hence his views will influence the decision on diagnosis, treatment and safety of the patient. He should be able to act independently in meeting his responsibilities and must be answerable only to the highest level of authority in the institution. This should be recognised by the national and state health authorities and medical physicists should be accorded a status similar to that of the physician / therapist / radiologist. Proper working conditions and facilities should be provided in order to attract the best physicists. Unfortunately, this is not the situation in India. The Medical Council of India (MCI) is yet to recognise medical physics as an independent discipline. The appeal is pending with MCI for more than a decade. As a result there is no uniformity in the working conditions, salary structure and career opportunities for medical physicists.

Organisation of the Medical Physicists

It is reported that the first medical physicists to be employed full time in radiotherapy departments were F. Volz in Munich Hospital in Germany and S. Russ in Middlesex Hospital in London. This was around 1912. Since then the number of full-time medical physicists has increased steadily and is presently estimated to be about 10,000 the world over.

The first society of medical physicists, the Hospital Physicists Association was founded in Great Britain in 1943. In 1956 the Council of Medical Physics was created as a Standing Committee of the Board of Trustees of the American Medical Association and in 1958 the American Association of Physicists in Medicine was founded. A number of countries followed suit. The International Organisation for Medical Physics was established in 1963. Similarly, the European Federation of Organisation for Medical Physics, bringing all the European societies under its umbrella, was formed in 1980.

Responsibilities of Medical Physicists in India
Prepared & Published by Radiological Physics Division,
Babha Atomic Research Center, Bombay – 400 085.
Ph: 022 – 2556 3060 Ext: 2201

In India, medical physics activities started in the mid 40s with the appointment of Dr. Ramaiah Naidu as the first medical physicist at the Tata Memorial Hospital, Bombay with a responsibility to set up and operate a radon plant for cancer treatment. Today there are about 600 medical physicists in the country. Eventhough the annual growth rate in the number of medical physicists is reported to be the highest in India, the total number is inadequate for the size of the population. While India has less than one medical physicist per million population, it ranges between 5 to 20 in developed countries. This also reflects upon the meagre facilities for x-ray diagnosis and radiation therapy of cancer in India.

The Association of Medical Physicists of India was founded in 1976 with the objective of encouraging the application of physics in medicine. It provides a forum for medical physicists in the form of annual conferences (at national and international levels) and publication of a quarterly Journal of Medical Physics for the exchange of ideas and dissemination of new knowledge. The Association collaborates with similar organisations in the world to raise the quality of medical physics in India. Currently it has an active membership of about 800, comprising of physicists, radiotherapists, radiologists and engineers. The wide spectrum of membership reflects the multidisciplinary nature of medical physics.

Responsibilities of Medical Physicists in India
Prepared & Published by Radiological Physics Division,
Babha Atomic Research Center, Bombay – 400 085.
Ph: 022 – 2556 3080 Ext: 2201

Annexure 1

Duties and Functions of the Radiation Safety Officer

(Section 13, Radiation Protection Rules – 1971)

The duties and functions of the Radiation Safety Officer in any radiation installation shall be as follows:

(a) to take all necessary steps aimed at ensuring that the dose limits are not normally exceeded;

(b) to instruct the radiation workers under his charge on the hazards of radiation and on suitable safety measures and work practices aimed at minimising exposure to radiation and contamination;

(c) to carry out leakage tests on sealed sources as specified in rule 34;

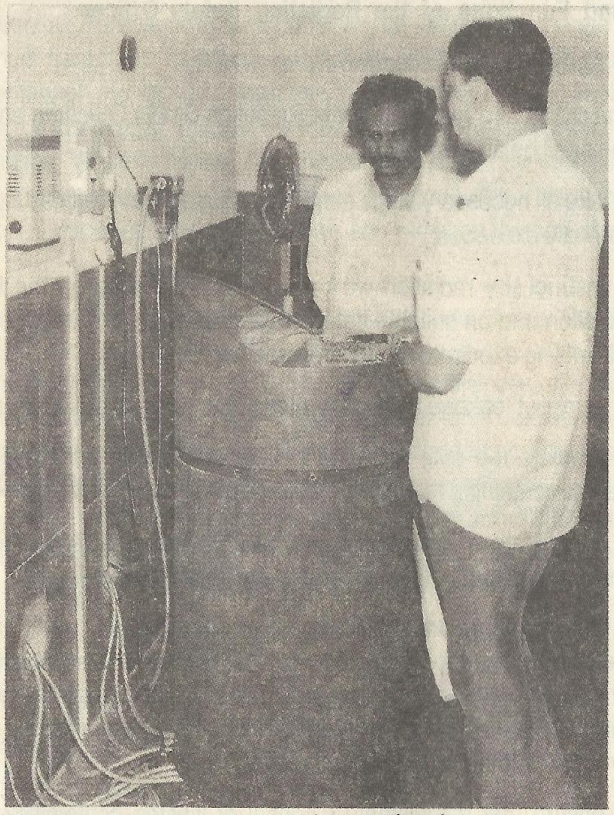
(d) to regulate the safe movement of all radioactive materials (including wastes containing radioactive materials) within the area under his charge;

(e) to investigate and initiate prompt and suitable remedial measures in respect of any situation that could lead to radiation hazards;

(f) to ensure that reports on all hazardous situations (including situations of the type referred to in rule 47 or as laid down in the notifications issued by the competent authority regarding dose limits) along with details of any immediate remedial measures that may have been initiated, are made available immediately to his employer;

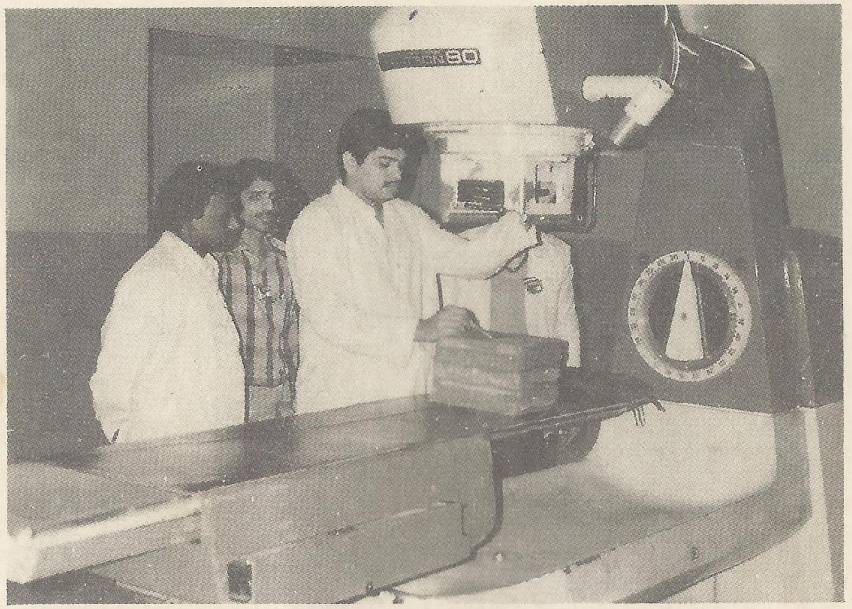
(g) to ensure that the ultimate disposal of wastes containing radioactive materials is done in a manner approved by the competent authority.

AMPI

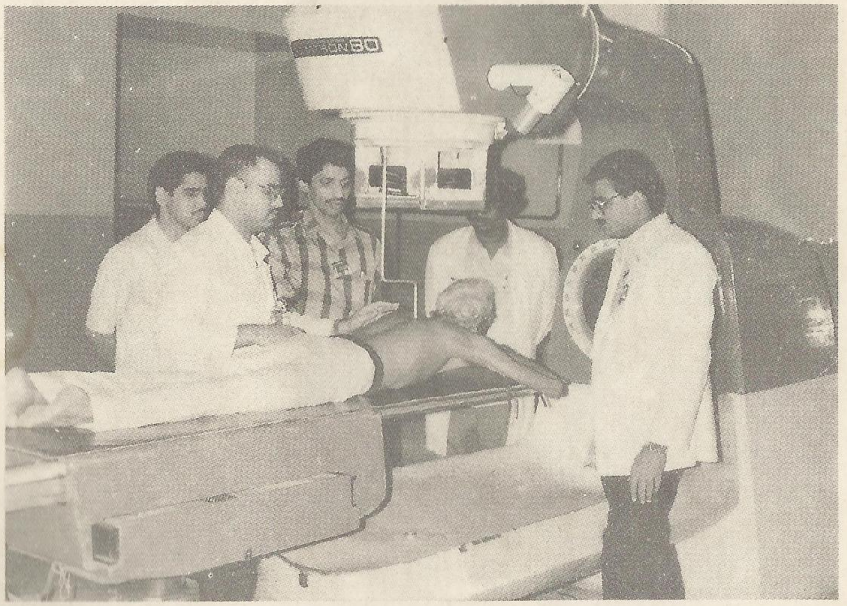


Physicist training a technologist in the operation of remote after-loading brachytherapy system

Prepared and published by Dr. M.S.S. Murthy, Secretary, Association of Medical Physicists of India, C/o Radiological Physics Division, Bhabha Atomic Research Centre, Bombay 400085; Phone 556 3060 Ext. 2201; and printed by him at DIGITS, 3, Jeevan Prakash, Annexe, Senapati Bapat Marg, Bombay 400 016. Phone 4306592.



Teaching physical principles of radiotherapy to technologists



Patient care in radiotherapy is a team work involving physicists, therapists and technologists

AMPI

ASSOCIATION OF MEDICAL PHYSICISTS OF INDIA

(An affiliate of INDIAN NATIONAL SCIENCE ACADEMY &
INTERNATIONAL ORGNIZATION FOR MEDICAL PHYSICS)

AIMS AND OBJECTIVES

- To promote the application of PHYSICS to Medical and Biological Sciences.
- To encourage Research & Development and Education in the field of MEDICAL PHYSICS.
- To provide a forum for persons engaged or interested in the field of MEDICAL PHYSICS and to arrange scientific meetings and discussions.
- To disseminate world-wide information in this field to all members of the ASSOCIATION and to participate actively in IOMP's programmes on MEDICAL PHYSICS.

ONGOING ACTIVITIES

- Organisation of ANNUAL CONFERENCE / WORKSHOPS / SEMINARS on MEDICAL PHYSICS - fifteen annual conferences organised so far.
- Publication of a quarterly JOURNAL OF MEDICAL PHYSICS.
- TRAVEL FELLOWSHIPS for advanced training in MEDICAL PHYSICS.
- Publication of EDUCATIONAL material in MEDICAL PHYSICS for students and general public.

INTERNATIONAL CONFERENCES

International Conference on Medical Physics and Radiation Safety (ICMP-92), Bombay, 1992.

Tenth International Conference on Use of Computers in Radiation Therapy, Lucknow, 1991.

Asian Regional Conference on Medical Physics, in collaboration with IOMP, Bombay 1986.

Seminar on Radiation Protection including Development of Radiological Physics in India (jointly organized by BARC and WHO, Regional Office for South East Asia), Bombay, 1976.

AMPI PUBLICATIONS

JOURNAL OF MEDICAL PHYSICS – A quarterly publication since 1976.

Proceedings of the International Conference on Medical Physics and Radiation Safety (ICMP – 92), published as Abstracts of Proferred Papers and Poster Presentations [Medical Physics Bulletin 17(3), 1992].

Invited Talks [Medical Physics Bulletin 17(4), 1992].

A special issue on Use of Computers in Radiation Therapy [Medical Physics Bulletin 16(2), 1991].

Membership Directory 1990.

Selected Topics on Physics of Radiotherapy and Imaging (1988).

Proceedings of the Asian Regional Conference on Medical Physics [Medical Physics Bulletin 11(3&4) 1986].

Physical Aspects of High Energy Electron Accelerators (1983).