H E A L T H

Technologies for Better Quality of Life

RADIOPHARMACEUTICALS

Radiopharmaceuticals are drug formulations containing radioisotopes and are suitable for administration in humans for diagnosis and therapy of various diseased states. Radiopharmaceuticals have revolutionized the medical field by their ability to provide static as well as dynamic images of internal organs in a noninvasive manner as well as by offering efficacious therapy of certain diseases.

Radiopharmaceutical production facility at BRIT

Diagnostic radiopharm-aceuticals are used to derive detailed description of the morphology and dynamic functioning of the various internal organs of the body. The radiophar-maceutical accumulated in an organ of interest emit gamma radiation which are used for imaging of the organs with the help of an external imaging device called gamma camera. A typical example is the imaging of a neuro-endocrine-tumour using ^{131}I-meta-iodobenzyl guanidine (mIBG).

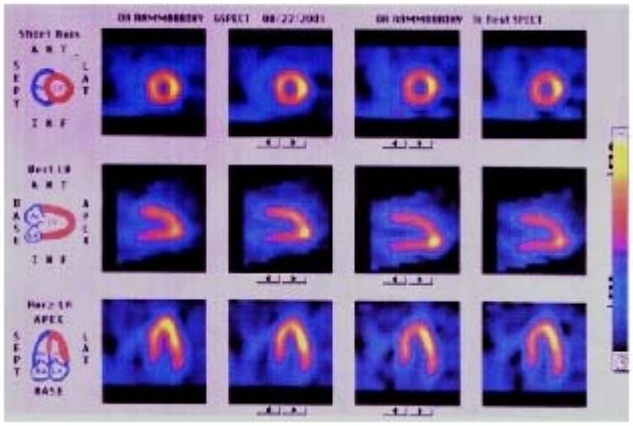
Therapeutic Radiopharmaceuticals are radiolabeled molecules designed to deliver therapeutic doses of ionizing radiation to specific diseased sites. Therapeutic applications of radiopharmaceuticals have emerged from the concept that certain radionuclides possessing particulate emission such as alpha and beta radiations or low-energy low-range electrons (Auger electrons) possess the ability to destroy diseased tissues. The dual facets of these agents constitute either curative or palliative measures in treatment modalities. Some examples are :

^{131}I- Sodium iodide - Thyrotoxicosis and thyroid cancer
^{153}Sm- EDTMP - Palliative treament of metastatic bone pain
^{166}Ho-HA particles - Rheumatoid arthritis

A shielded facility for the production of iodine-131 capsules for therapeutic applications

Technetium Radio-pharmaceuticals are used in over 80% of the nuclear medicine studies the world over and hence aptly called the "work-horse" of diagnostic nuclear medicine. The ideal nuclear properties of ^{99m}Tc constitutes its 140 keV gamma photon with 89% abundance which is optimum for imaging with gamma cameras available in nuclear medicine centers. Its half life of 6 hours, though sufficiently long for preparation of the radiopharmaceutical, performing its quality control and injecting into the patient for imaging studies, is at the same time short enough to minimize the radiation dose. A host of technetium radiopharmaceuticals for diagnosis of a wide spectrum of diseased states are now available.

^{99m}Tc-MDP - Bone scintigraphy
^{99m}Tc- ECD - Brain perfusion imaging
^{99m}Tc- MIBI - Myocardial perfusion imaging
^{99m}Tc- DTPA- Renal function studies



Perfusion images of heart using ^{99m}Tc-MIBI. The series of pictures in the top is a normal image and the ones in the bottom show perfusion abnormalities.

The rapid growth of ^{99m}Tc radiopharmaceuticals is due to the development of ^{99}Mo/^{99m}Tc generator technology which is capable of giving the 6 h half life ^{99m}Tc at the hospital site over a period of one week. Availability of a wide variety of

lyophilized cold kits for formulation of ^{99m}Tc radiopharmaceuticals have further augmented the growth of the usage of ^{99m}Tc radiopharmaceuticals. Cold-kits provide pre-packed set of sterile ingredients designed for the preparation of a specific ^{99m}Tc-radiopharmaceutical at the hospital radiopharmacy attached to the nuclear medicine department.

Radiopharmaceuticals for positron emission tomography

Radiopharmaceuticals that are prepared using radioisotopes produced in particle accelerators (particularly cyclotron), decay by electron capture and/or positron emission. Short-lived positron emitting radionuclides provide suitable alternatives to the reactor produced isotopes for diagnostic imaging. The merits of coincidence detection of annihilation photons arising from decay of a positron-emitting radioisotope within an organ of interest provide superior images in a positron emission tomography (PET). ^{18}F-FDG (fluoro-2-deoxyglucose), aptly named as the 'molecule of the millennium' is widely used over the world as a versatile PET tracer and has proven its clinical utility in oncology, neurology and cardiology.

The medical cyclotron facility for the production of short lived positron emitting radionuclides

Radiopharmaceuticals undergo stringent **quality control and quality assurance** tests to ensure pharmaceutical safety, efficacy and purity. Physicochemical, radiochemical and biological tests are carried out to ensure, radionuclidic purity, radiochemical purity, pharmaceutical efficacy, sterility, and apyrogenicity of the radiopharmaceuticals.

A **radiopharmacy** set-up located in a hospital is responsible for the preparation of the final dose for the administration of radiopharmaceutical and also for the formulation of ^{99m}Tc-radiopharmaceuticals. The major responsibility of a hospital radiopharmacy are dosage preparation, quality control and quality assurance of the radiopharmaceutical, safe-guarding against radiation exposure of staff as well as patients and radioactive waste management.

The **nuclear medicine department** encompasses the hospital radiopharmacy along with the scintigraphy unit. The radiopharmaceutical is administered to a patient by a physician trained in nuclear medicine and the patient is imaged under a suitable instrument such as a planar gamma camera, a single photon emission tomography (SPECT) or a positron emission tomography (PET) machine. The latter two are capable of giving three dimensional images of the organs or tissues which show uptake of the radiopharmaceutical.

The Board of Radiation and Isotope Technology (BRIT) is responsible for the production, quality control, and supply of radiopharmaceuticals in India. BRIT is routinely manufacturing about 25 radiopharmaceuticals and catering to the requirements of about 70 nuclear medicine centres in India, in addition to exporting the radiopharmaceuticals to a few neighboring countries. About 300,000 diagnostic studies and 15,000-20,000 therapies are carried out annually using the radiopharmaceuticals provided by BRIT.

Fully programmable chemistry modules and dispenser used for the synthesis and sterile dispensing of injectable PET radiopharmaceuticals

Owing to the efforts of the Department of Atomic Energy in production and supply of radiopharmaceuticals as well as in human resource development both at technologist and physicians level, nuclear medicine department are currently available in all major cities in India. Major Institutions such as the All India Institute of Medical Sciences, New Delhi; Post Graduate Institute of Medical Education and Research, Chandigarh, Sanjay Gandhi Post Graduate Institute of

Medical Sciences, Lucknow, Christian Medical College, Vellore, Regional Cancer Centre, Tiruvanthapuram, Kidwai Memorial Institute of Oncology, Banglaore, Apollo Group of Hospitals etc. are among the major users of radiopharmaceuticals in India. From the major metros, nuclear medicine has spread into smaller cities such as Ludhiana in Punjab, Manipal in Karnataka, Simla in Himachal Pradesh, Trissur in Kerala, Agra in Uttar Pradesh, Coimbatore in Tamilnadu, to name a few.

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