RADIOPHARMACY

Radiopharmacy is an integral part of a Nuclear Medicine Department that deals largely with the preparation, compounding, Quality Control (QC), and dispensing of radiopharmaceuticals and radioisotopes for human use. Usually, the Radiopharmacy comprises a radiochemistry laboratory especially equipped with a dose calibrator, a biological safety class III cabinet for cell labelling or cold kit manufacturing, or a Biological Safety cabinet class II for cell labelling. Radiochemists or Radiopharmacists are the personnel who perform these functions at large hospitals or medical centres. They are involved in manufacturing cold kits and in developing new agents and procedures.

Radiopharmaceuticals:

A radiopharmaceutical may be defined as a pharmaceutical substance containing radioactive atoms (radionuclide) within its structure. It is generally used for diagnostic purposes but may also be used for therapeutic treatment. Radiopharmaceuticals are formulated in various chemical and physical forms to target specific organs of the body. The radiopharmaceutical is administered to the patient via a small injection, inhalation, or swallowed as a tablet or liquid, depending on which type of scan ordered. Most radiopharmaceuticals used in diagnostic Nuclear Medicine procedures emit gamma radiation.

The gamma radiation emitted from the radiopharmaceutical is detected or measured externally by a SPECT camera. The SPECT camera is used by Technologists to perform static or dynamic images enabling Nuclear Medicine Physicians to evaluate the functional and/or morphological characteristics of the organ of interest. SPECT cameras can also perform tomographic imaging where 3D slices are generated (similar to CT scanning).

An ideal radiopharmaceutical is one that rapidly and avidly localises within the organ under investigation, remains in it for the duration of study, and is quickly eliminated from the body. No single ideal agent exists, so a radionuclide and a chemical compound are selected to achieve the best compromise.

Basically, the wide range of radiopharmaceuticals available in Nuclear Medicine can be divided into four major groups according to application: imaging agents, in-vivo function agents, agents for in-vitro studies, and therapeutic agents.

a) Imaging agents:

The majority of radiopharmaceuticals are used in extremely small tracer amounts for diagnostic imaging. The selection of an imaging agent is based on its ability to localise within the organ of interest and a SPECT camera is used to acquire its dynamic or static image. Dynamic scans are useful for evaluating the functional

status of the organ based on the rate of accumulation and clearance of the tracer. Static images provide information on the morphology of the organ (size, shape, presence or absence of space occupying lesions) based on the pattern of radionuclide distribution. Tomographic images allow 3D images of the radionuclide distribution to be acquired then processed into slices.

b) In-vivo function agents:

Radioactive tracer agents are also used to measure the function of a particular organ by counting radioactivity emitted from the body in blood samples or in urine. Such studies are based upon the localisation, dilution, concentration, or excretion of radioactivity following administration of the radiopharmaceutical. For example ^{51}Cr-sodium chromate is used for determining red cell volume and red cell survival studies by measuring the dilution of a known amount of the intravenously injected ^{51}Cr-labelled red cells. It is essential that the chemical integrity of these radiopharmaceuticals are not altered as a result of the radio-labelling procedure. ^{51}Cr-EDTA (Ethylene Diamine Tetraacetic Acid) is frequently used for determining Glomerular Filtration Rate (G.F.R.)

c) Agents for In-vitro Studies:

These agents are radiopharmaceuticals that are not injected into patients, but used to measure chemical substances, hormones, or drugs in patient's blood sample. The majority of tests are based on the radioimmunoassay (RIA) principle making use of the antigen-antibody immune reaction. These tests are frequently used to measure plasma levels of thyroid hormones, cortisol, digoxin, and a number of other compounds. In many institutions, RIA falls under the domain of Clinical Chemistry/ Chemical Pathology.

d) Therapeutic Agents:

The commonest therapeutic procedure is the use of ^{131}I- sodium iodide for the treatment of hyperthyroidism and ablation of residual functioning thyroid tissue in differentiated thyroid carcinoma. ^{131}I- sodium iodide emits both beta and gamma radiation enabling both diagnostic and therapeutic procedures to be performed; larger amounts (>1GBq) of the radiopharmaceutical is used for therapeutic treatment of thyroid cancer. With an intent to selectively destroy diseased tissue, various other beta emitters are occasionally used as an adjunct to conventional procedures cancer therapy. ^{89}Sr-Strontium chloride (Metastron) and ^{153}Sm-EDTMP (Quadramet) are used as alternatives and adjunct to external beam therapy for the palliation of bone pain from bone metastasis secondary to prostate or breast carcinoma following failure of hormone or chemotherapy. Occasionally, ^{32}P-sodium phosphate also has been used for treatment of polycythemia rubra vera (excess red blood cells).

Common Radiopharmaceuticals:

The most commonly used gamma emitting radionuclide in Nuclear Medicine is ^{99m}Technetium, which is labelled to different types of cold kits (pharmaceuticals) to formulate diagnostic imaging agents (radiopharmaceuticals). The following is a list of commonly used radiopharmaceuticals in Nuclear Medicine.

Radiopharmaceutical	**Half-Life**	**Uses**
^{32}Phosphorus	14.3 days	Treatment of excess red blood cells (polycythemia rubra vera)
^{99m}Tc-Pertechnetate	6.1 hours	Thyroid and gastric tissue imaging
^{99m}Tc-HDP or MDP	6.1 hours	Bone imaging
^{99m}Tc-Sestamibi	6.1 hours	Myocardial perfusion & parathyroid gland imaging
^{99m}Tc-DTPA or MAG_3	6.1 hours	Renal perfusion imaging & differential function
^{51}Cr-EDTA		GFR estimation
^{99m}Tc-DMSA	6.1 hours	Renal cortical imaging & differential function
^{99m}Tc-Technegas	6.1 hours	Lung ventilation imaging
^{99m}Tc-MAA	6.1 hours	Lung perfusion imaging
^{18}Fluorine-FDG	109.9 mins	Diagnose certain types of cancer; the evaluation of myocardial viability; measure of glucose metabolism.
^{131}Iodine	8.04 days	Diagnose and treat thyroid cancer
^{123}Iodine-MIBG	13.22 hrs	Adrenal medulla imaging & phaeochromocytoma
^{89}Strontium	50.5 days	Palliative treatment for bone pain
^{153}Samarium-EDTMP	46.7 hrs	Reduce pain associated with bone metastases
^{111}In-Octreotide	67.2 hrs	To diagnose gastro-entero-pancreatic neuro-endocrine (GEP) and carcinoid tumours
^{90}Yttrium-Citrate	64.1 hrs	Radiation Synovectomy for joint effusions