Radiopharmaceuticals

Aims and Objectives

By the end of this lesson you will be able to:

- describe the desirable properties of an ideal radiopharmaceutical used for diagnostic imaging
- describe how tecnecium-99 is prepared
- list the quality control mechanisms necessary for the use of radiopharmaceuticals.

Radiopharmaceuticals are medicinal products which emit radiation. They are mostly used for diagnostic purposes, for example they can be used to image different organs or to monitor various bodily functions. They can also be used for therapy to treat diseased organs or destroy tumours.

Diagnostic Imaging

The different organs of the body have different biological and chemical properties. By making use of these differences pharmaceuticals can be produced which accumulate in different organs of the body. A radiopharmaceutical is formed by attaching a radioisotope to normal molecules found in the body (this is called radioactive labelling). The structure and function of different organs can be determined by observing the distribution of the radiopharmaceutical. The radiation emitted from the radiopharmaceutical is detected by a special camera called a gamma camera.

A radiopharmaceutical is given to a patient in a dose which is just enough to obtain the information required. The actual amount of radiation received by the patient is very small.

The most widely used radioisotope in medicine is **technetium-99m.** It can be combined with many substances to produce many different radiopharmaceuticals and it is used in about 80% of nuclear medicine procedures. It has almost ideal characteristics for a radiopharmaceutical:

- It has a **half-life of 6 hours** - long enough to obtain images or examine biological processes, short enough to limit radiation exposure to patient.

- It **emits gamma rays** of high enough energy to be detected by gamma camera but low enough not to cause damage to the patient (alpha radiation would not get out of the body, also it is highly ionising and therefore damages the body, beta radiation would be partly absorbed and is also ionising).

- It decays to a suitable daughter isotope.

- Its chemistry enables it to form many compounds that are biologically active, therefore it can be made into many different radiopharmaceuticals, for example 99mTc-diphosphate used for bone imaging, 99mTc-sodium pertechnetate used in brain imaging.

Some Uses of Technetium-99m
Imaging of coronary arteries in the heart (myocardial perfusion imaging). Also used to image heart muscle.

Imaging of the skeleton (bone growth, bone disease), imaging of brain, thyroid gland, lungs, liver, kidney (structure and filtration rate).

Measurement of blood volume.

Location of infection.

Preparation of Tecnetium-99m
Tecnetium-99m (99mTc) is a product of the decay of molybdenum-99 (which is a product of the fission of uranium-235). Because the half life of 99mTc is quite short it is necessary to have a way of producing it when needed for a clinical purpose.

Technetium generator
www.apinfo.co.uk/images/dby/DRYTEC.jpg

Hospitals are supplied with a technetium generator (commonly known as a 'cow'). The generator consists of a glass tube enclosed in a lead pot. Inside the glass tube there is molybdenum-99 which has a half-life of 66 hours. The molybdenum-99 decays to 99mTc. When 99mTc is required saline is run through the generator and it is washed out with the saline. This process is known as 'milking' the 'cow'. The imaging agents are supplied separately, when they are mixed with the saline containing the 99mTc the radiopharmaceutical is formed and is given to the patient. The generator has to be recharged every two weeks from a nuclear reactor.

Quality Control

When a pharmaceutical is given to a patient it is important that it conforms to certain standards so that patient safety is protected. The following properties have to be monitored in order to assure the quality of radiopharmaceuticals:

- radionuclide concentration - this is the concentration of the desir ed radionuclide. There may be contamination with other products e.g. from the parent nuclide, for example molybdenum from a technetium generator.

- radiochemical purity - this is the proportion of the radionuclide present in the stated chemical form.

The following are quality requirements for all pharmaceutical agents:

- chemical purity
- sterility
- apyrogenicity - (does not cause a rise in body temperature)
- absence of foreign particles
- pH

Medical Physics Techniques - Contents of Term Two

Medical uses of a range of radionuclides.
Radiopharmaceuticals - preparation and quality control mechanisms.
Desirable biological and radiological properties of radionuclides used for imaging.

Main components and operating principles of the gamma camera.
Image production and processing in a gamma camera.

Different x-ray tubes and techniques used in clinical diagnosis.
Quality assurance.

Transducer designs for pulse echo and Doppler ultrasound applications.