NAME: EGHAGHARA ESE ESTHER

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1.

**RADIOACTIVE TRACERS**

Tracers are substances with atomic or nuclear, physical, chemical or biological properties that can help identify, observe or follow the behavior of various physical, chemical or biological processes. Radioactive tracers are widely used to diagnose industrial reactors, for instance by measuring the flow rate of liquids, gases and solids.

Radioactive tracers are made up of carrier molecules that are bonded tightly to a radioactive atom. These carrier molecules vary greatly depending on the purpose of the scan. Some tracers employ molecules that interact with a specific protein or sugar in the body and can even employ the patient’s own cells. For example, in cases where doctors need to know the exact source of intestinal bleeding they may radiolabel (add radioactive atoms) to a sample of red blood cells taken from the patient. They then reinject the blood and use a SPECT scan to follow the path of the blood in the patient. Any accumulation of radioactivity in the intestines informs doctors of where the problem lies.

For most diagnostic studies in nuclear medicine, the radioactive tracer is administered to a patient by intravenous injection. However, a radioactive tracer may also be administered by inhalation, by oral ingestion, or by direct injection into an organ. The mode of tracer administration will depend on the disease process that is to be studied.

Approved tracers are called radiopharmaceuticals since they must meet FDA’s exacting standards for safety and appropriate performance for the approved clinical use. The nuclear medicine physician will select the tracer that will provide the most specific and reliable information for a patient’s particular problem. The tracer that is used determines whether the patient receives a SPECT OR PET scan.

Radioactive tracers utilize the positive qualities of radioactivity, the ability to emit a signal, while minimizing the negative effects. Isotopes use elements with a short half-life to reduce the dangers of radioactive exposure to the patient. A half-life represents the amount of time it takes for one-half of a substance’s radioactivity to decay. For example, a material with half-life of six hours will lose half of its radioactivity in six hours and then another one-half at the 12-hour mark, leaving one fourth of its strength. The shorter the half-life the less radioactive exposure.

The most common radioactive isotope used in radioactive tracers is technetium 99m, used in almost 30 million procedures in 2008, representing 80% of all nuclear medicine procedures according to World Nuclear Association. It is an isotope of an artificial element, technetium with a half-life of six hours, which provides enough time to perform the necessary diagnostic procedures, but provides patient safety. It is versatile and can be targeted to a specific organ or body part and emits gamma rays that provide the necessary information. Other radioactive tracers include iodine-131 for thyroid conditions, iron-59 iron to study metabolism in the spleen and potassium-42 for potassium in the blood.

A major use of radioactive tracers involves computed X-ray tomography or CT scans. These scans constitute approximately 75% of medical procedures with tracers. The radioactive tracer produces gamma rays or single photons that a gamma camera detects. Emission come from different angles and a computer uses them to produce an image. The treating physician orders a CT scan that targets a specific area of the body like the neck or chest, or a specific organ, like the thyroid.

Positron emission tomography, or PET, represents the latest technology to use radioactive tracers. It provides a more precise image and is used frequently in oncology with fluorine-18 as the tracer. PET is also used in cardiac and brain imaging with carbon-11 and nitrogen-13 radioactive tracers. Another innovation involves the combination of PET and CT into two images known as PETCT.

**PREPARING A RADIOTRACER INVESTIGATION**

Various requirements need to be met before running a radiotracer investigation. The most important of these is to select an appropriate radiotracer. It is of fundamental importance that the radiotracer compound behaves in the same way as the material to be traced. To obtain reliable and meaningful results, an industrial radiotracer must also meet other basic requirements, such as a suitable half-life and radiation energy, as well as physical and chemical stability. It must also be easily and unambiguously detectable. Before injecting a tracer into a system, it must be clear how it will behave inside it. In certain circumstances, the tracer may undergo decomposition, phase change, undesirable absorption and adsorption, or chemical interaction with system constituents. All this can lead to incorrect results. It is often difficult to meet all the requirements of an ideal tracer. Certain compromises have to be made. Even if a radiotracer meets the required criteria, it may not be available to tracer groups in developing countries.

2.

**APPLICATION OF RADIOACTIVE TRACER IN MEDICINE**

APPLICATION OF TECHNETIUM-99m IN MEDICINE

Techetium-99m is a metastable nuclear isomer of technetium-99(itself an isotope of technetium), symbolized as 99m Tc, that is used in tens of millions of medical diagnostic procedures annually, making it the most commonly used medical radioisotope.

Technetium-99m is used as a radioactive tracer and can be detected in the body by medical equipment (gamma cameras). It is well suited to the role, because it emits readily detectable gamma rays with a photon energy of 140keV (these 8.8 pm photons are about the same wavelength as emitted by conventional X-ray diagnostic equipment) and its half-life for gamma emission is 6.0058 hours (meaning 93.7% of it decays to 99Tc in 24 hours).

Technetium-99m was discovered as a product of cyclotron bombardment of molybdenum. This procedure produced molybdenum-99, a radionuclide with a longer half-life (2.75 days), which decays to Tc-99m. At present, molybdenum-99 is used commercially as the easily transportable source of medically used Tc-99m. In turn this Mo-99 is usually created commercially by fission of highly enriched uranium in aging research and material testing nuclear reactors in several countries.

Technetium-99m Is used in 20 million diagnostic nuclear medical procedures every year. Approximately 85% of diagnostic imaging procedures in nuclear medicine use this isotope as radioactive tracer. 99mTc for imaging and functional studies of the brain, myocardium, thyroid, lungs, liver, gallbladder, kidneys, skeleton, blood and tumors. Depending on the procedure, the 99mTc is tagged (or bound to) a pharmaceutical that transports it to its required location. 99mTc is chemically bound to exametazime (HMPAO) the drug is able to cross the blood- brain barrier and flow through the vessels in the brain for cerebral blood flow imaging. This combination is also used for labelling white blood cells (99mTc labeled WBC) to visualize sites of infection.

Bone scan

The nuclear medicine technique commonly called the bone scan usually uses Tc- 99m. it is not to be confused with the ‘’bone density scan’’, DEXA, which is allow exposure X-ray test measuring bone density to look for osteoporosis and other diseases where bones lose mass without rebuilding activity. The nuclear medicine technique is sensitive to areas of unusual bone rebuilding activity, since the radiopharmaceutical is taken up by osteoblast cells which build bone. The technique therefore is sensitive to fractures and bone reaction to bone tumors, including mestases. For a bone scan, the patient is injected with a small amount of radioactive material, such as 700-1,100 MBq (19- 30mCi (of 99mTc- Medtronic acid and then scanned with a gamma camera. Medtronic acid is a phosphate derivative which can exchange places with bone phosphate in regions of active bone growth, so anchoring the radioisotope to that specific region.

Myocardial perfusion imaging

Myocardial perfusion imaging (MPI) is a form of functional cardiac imaging used for the diagnosis of ischemic heart disease. The underlying principle is under conditions of stress, diseased myocardium receives less blood flow than normal myocardium. MPI is one of several types of cardiac stress test. As a nuclear stress test the average radiation exposure is 9.4mSV which compared to a typical 2 view chest X-ray (.1mSV) is equivalent to 94 chest X-rays. Several radiopharmaceuticals and radionuclides may be used for this each giving different information. In the myocardial perfusion scans using Tc-99m, the radiopharmaceuticals. Myocardial stress is induced either by exercise or pharmacologically with adenosine dobutamine or dipyridamole (persantine), which increase the heart rate or by regadenoson(lexican) a vasodilator

Meckel’s diverticulum

Pertechnetate is actively accumulated and secreted by the mucoid cells of the gastric mucosa, and therefore, technetate (vii) radiolabeled with Tc-99m is injected into the body when looking for ectopic gastric tissue as is found in a Meckel’s diverticulum with Meckel’s scans.