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**17/MHS01/291**

**MLS 314(MEDICAL PHYSICS)**

**300LEVEL**

**RADIOACTIVE TRACERS**

Radioactive tracer,radiotracer or radioactive label,is a chemical compound in which one or more atoms have been replaced by a radionuclide so by virtue of its radioactive decay it can be used to explore the mechanism of chemical reactions by tracing the path that the radioisotope follows from reactants to products.

Radioactive tracer is made by proton bombardment of 18-O in a cyclotron or linear particle accelerator.It is an important isotope in the radiopharmaceutical industry.It is used to make labeled **fluorodeoxyglucose (FDG)** for application in PET scans.

The type of radiation that is used in tracers is BETA RADIATION.Beta radiation is used for tracers and monitoring the thickness of materials.Doctors may use radioactive chemicals called tracers for medical imaging.Certain chemicals concentrate in different damaged or diseased parts of the body,and the radiation concentrates with it.

Tracers are made to act as naturally as possible,there is a minimal possibility of side effects.Tests that involve the use of other non-radioactive drugs may have the small possibility of side effects,which will be explained to you by the technologist performing your test.

Radioactive tracers are widely used to diagnose industrial reactors,for instance by measuring the flow rate of liquids,gases and solids.A radioactive tracer is a chemical compound in which one or more atoms have been replaced by a radioisotope. A radioactive tracer is used to detect an image tissues,

not affect them with radiation,so it uses only small amounts of radioactive material.As no other processes in the human body produce gamma radiation,the energy produced by the tracer stands out clearly,even in small quantities.

Tracers are live ammunition.They are designed to illuminate the trajectory of the bullet so that the rifleman may see where his rounds are hitting.These are especially useful at night.On a machine gun belt is common for every 5th round to be a tracer.

In a radioactive tracer technique,radioactive nuclides are used to follow the behavior of elements or chemical species in chemical and other processes.This is realized by means of radioactivity measurement.

A radioactive tracer is a chemical compound in which one or more atoms have been replaced by a radioisotope.Monitoring its radioactive decay,a radiotracer can be used to explore the mechanism of chemical reactions.They are also used for flow visualisation through different technologies,such as **Single Photon Emission Computed Tomography(SPECT),Positon Emission Tomography(PET) and Computed Radioactive Particle Tracking(CARPT).**

Radiotracer technology is playing a more and more important role in industry.It is used to diagnose specific causes of inefficiency in a plant or process operation and to genrally investigate processes in industries and those related environments where a great cost-benefit ratio can be gleaned from process optimization and troubleshooting,such as in the transport of sediments.It is expected that this important role will continue to expand,especially if students and engineers are exposed in their academic training to the many possibilities of this tool for research,development and application.

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,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.

**APPLICATION OF TRACER IN MEDICINE**

In medicine,tracers are applied in a number of tests,such as 99mTc in autoradiography and nuclear medicine,including **Single Photon Emission Computed Tomography(SPECT),Positon Emission Tomography(PET) and scintigraphy.Tracers with differentg half - lives are used fpr each stage of hydraulic fracturing.**

The radioactive atoms,that are radioisotopes,have brought a lot to biology.They are also at the core of nuclear medicine.These unstable atoms behave like ordinary stable atoms apart from the one and extremely short moment when they emit their radiation.Their chemical and physical properties are those of the species to which they belong.They bind like them with other atoms to form molecules.

The alpha,beta,or gamma rays they emit during their fugitive radioactive decay signal their presence.Tiny objects of the infinitely small.radioisotopes are innumerable even in minute proportion in the matter.Thanks to the rays they emit,they can be located using good detectors.They are the spies of the living,the tools of diagnosis.

In therapy,the rays are used as weapons.One would shell tumors with an external source or by means of radioactive implants located near the malignant cells.

The use of radioisotopes for diagnosis is by far the most widespread.

Ever since the 1934 discovery of artificial radioactivity,doctors have been armed with a panoply of radioactive isotopes for use as markers or tracers.Thanks to these radioactive isotopes it is now possible to follow the path of a single atom or chemical element around the body without disturbing its physical,chemical or biological behavior.

In the areas of biology and medicine,nuclear tracers are usually radio-pharmaceutical products whose molecules contain a radioactive element - a marker.The emissions of radiations by such atoms allow to follow the path or the metabolism of these tracers in the body .Tracers can be reduced to a marker itself: this is the case of krypton 81m or xenon 133,noble gases used for lung scans.Markers can be also attached to objects other than molecules,such as albumin microspheres.

Medical tests of this kind involve administering a radioactive tracer,chosen carefully for its ability to follow a metabolism or provide information about the working of a given organ.The tracer can be an individual atom(for instance iodine 123),a marked molecule(such as a diphosphonate marked with technetium 99m), an hormone or even an antibody marked with an isotope.The isotope has to be chemically attached to the relevant molecule without altering its properties and metabolism.The bond must also be a solid one in order to follow the molecule and not an eventually shaken off radioactive atom.

So-called ‘**radio-pharmaceutical’ products {molecules containing radioactive isotopes} are generally inserted intravenously,though some can also be inhaled or even swallowed.**

**When it comes to internal body scans,the game is to localize the radio-pharmaceutical product inside the body from an external detection while exposing the body to a minimal dose of radiation.Gamma emitters are therefore the ideal radioelements: gamma rays are relatively low ionisers and simultaneously penetrative enough to be detected outside of the body.Another important property of the radioelement is its half-life,which has to be long enough to follow the biological process in question and yet short enough to avoid any unnecessary exposure.**

**Technetium 99m is by far the most commonly used radio-element(as it is used in 80-90% of all scintigraphy scans),as it allows for the exploration of numerous body parts and emits only gamma rays whose energy(of 140keV)is well adapted to the gamma-camera detectors. Beta-plus (positron) emitters are used in the field of ‘positron emission tomography’( PET scans).**

**In the field of metabolic therapy,beta-minus emitters are used to deliver a highly localized dose of radiation.**

**RADIO-ISOTOPES IN MEDICINE**

**-Nuclear medicine uses radiation to provide diagnostic information about the functioning of a person’s specific organs,or to treat them.**

**-Radiotherapy can be used to treat some medical conditions,especially cancer,using radiation to weaken or destroy particular targeted cells.**

**-Over 40million nuclear medicine procedures are performed each year,and demand for radio-isotopes is increasing at up to 5% annually.**

**-Sterilization of meical equipment is also an important use of radio-isotopes.**

**Radioactive Tracers application**

**Practitioners of nuclear medicine utilize small amounts of radioactive isotopes for diagnostic purposes.These isotopes,called radioactive tracers,enter the body by injection or ingestion.They emit a signal,ususally gamma rays,that can be identified.The medical provider targets a particular organ or body part.The tracer provides valuable information that assists in making a diagnosis.**

**Process**

**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 a 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.**

**Materials**

**The most common radioactive isotope used in radioactive tracers is technetium-99m,used in almost 30million procedures in 2008,representing 80percent 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 in the blood.**

**CT SCAN**

**A major use of radioactive tracers involves computed X-ray tomography or CT scans. Thses scans constitute approximately 75percent of medical procedures with tracers.The radioactive tracer produces gamma rays or single photons that a gamma camera detects.Emissions 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.**

**PET**

**Positron emission tomography,pr 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.**

**A Computed tomography(CT)scan allows doctors to see inside your body.It uses a combination of x-rays and a computer to create pictures of your organs,bones and other tissues.It shows more detail than a regular X-ray.You can get a CT scan on any part of your body.The procedure does not take very long, and it’s painless.**

**How Do CT Scans Work?**

**They use a narrow x-ray beam that circles around one part of your body.This provides a series of images from many different angles.A computer uses this information to create a cross-sectional picture.Like one piece in a loaf of bread,this two-dimensional (2D) scan shows a ‘’slice’’ of the inside of your body.**

**This process is repeated to produce a number of slices.The computer stacks these scans one on top of the other to create a detailed image of your organs,bones,or blood vessels.For example,a surgeon may use this type of scan to look at all sides of a tumor to prepare for an operation.**

**How Are CT Scans Done?**

**You’d probably get a scan at a hospital or radiology clinic.Your doctor might tell you not to eat or drink for a few hours before the procedure.You may also need to wear a hospital gown and remove any metal objects,such as jewelry.**

**A radiology technologist will perform the CT scan.During the test,you will lie on a table inside a large,doughnut-shaped CT machine.As the table slowly moves through the scanner,the x-rays rotate around your body.It is normal to hear a whirring or buzzing noise.Movement can blur the image,so you will be asked to stay very still.You may need to hold your breath at times.**

**How long the scan takes will depend on what parts of your body are being scanned.It can take anywhere from a few minutes to a half-hour.In most cases,you will go home the same day.**

**What Is It Used For?**

**Doctors order CT scans for a long list of reasons:**

**-CT scans can detect bone and joint problems,like complex bone fractures and tumors.**

**-If you have a condition like cancer,heart disease,emphysema,or liver masses,CT scans can spot it or help doctors see any changes.**

**-They show internal injuries and bleeding,such as those caused by a car accident.**

**-They can help locate a tumor,blood clot,excess fluid,or infection.**

**-Doctors use them to guide treatment plans and procedures,such as biopsies,surgeries,and radiation therapy.**

**-Doctors can compare CT scans to find out if certain treatments are working.For example,scans of a tumor over time can show whether it is responding to chemotherapy or radiation.**

**What Is a CT Scan with Contrast?**

**In a CT scan,dense substances like bones are easy to see.But soft tissues don’t show up as well.They may look faint in the image.To help them appear clearly,you may need a special dye called a contrast material.They block the x-rays and appear white on the scan,highlighting blood vessels,organs or other structures.**

**Contrast materials are usually made of iodine or barium sulfate.You might receive these drugs in one or more of three ways:**

**-Injection:The drugs are injected directly into a vein.This is done to help your blood vessels,urinary tract,liver or gall bladder stand out in the image.**

**-Orally:Drinking a liquid with the contrast material can enhance scans of your digesting tract,the pathway of food through your body.**

**-Enema:If your intestine are being scanned,the contrast material can be inserted in your rectum.**

**After the CT scan,you will need to drink plenty of fluids to help your kidneys remove the contrast material from your body.**

**What Are the Side Effects?**

**Some people are allergic to the contrast materials.Most of the time,the reaction is mild.It can lead to itchiness or a rash.In very few cases,the dye may trigger a life-threatening reaction.For this reason,your health care provider may want to monitor you for a short period after your CT scan.Tell your doctor about any allergies you have to medications,seafood or iodine.**

**Your doctor should know too,if you have diabetes and are taking the drug metformin.He will let you know if you should stop taking your medication before or after your procedure.**

**Although it is rare,contrast materials can lead to kidney problems.Let your doctor know if you have any kidney issues before the CT scan.**

**Clinical Application of CT scan**

**-Trauma**

**Trauma CT has changed over recent years in response to National Institute for Health and Care Excellence(NICE)and RCR guidelines and with the incorporation of the military protocol for whole body CT.Trauma scanning has improved both in terms of the volume and the value of data produced.Patients benefit from reduced risk due to less time spent in the scan room and faster diagnoses owing to better image quality.**

**-Diagnosis of diseases and staging of cancer**

**CT aids the diagnosis and surveillance of many diseases throughout the body including cancer.**

**-CT use in Nuclear Medicine/PET**

**CT is currently used in Nuclear Medicine for:**

**1.supplementing gamma camera images with anatomical information to help confirm aetiology(non-fused)**

**2.co-registration(fusion) of high quality anatomical information with physiological information produced from SPECT or PET imaging.**

**3.attenuation correction of SPECT and PET images.**

**CT image co-registration for SPECT and PET has become standard practice for many examinations,enabling a more accurate diagnosis and more accurate planning of treatment in oncology.There are also non-oncological uses for gamma camera.SPECT/CT e.g. in cardiac and MSK imaging.Fused data attenuation correction,improves image positional and functional data accuracy.**

**CT in nuclear medicine is further discussed in the professional document entitled Computerised Tomography (CT) scanners in Nuclear Medicine facilities; use by nuclear medicine practitioners from both radiographic and technologist backgrounds.**

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