



Cardiac Nuclear Medicine

Cardiac nuclear medicine imaging evaluates the heart for coronary artery disease and cardiomyopathy (diseases of the heart muscle). It also may be used to help determine whether the heart has been damaged by chemotherapy or radiotherapy. Nuclear medicine uses small amounts of radioactive materials called radiotracers that are typically injected into the bloodstream, inhaled or swallowed. The radiotracer travels through the area being examined and gives off energy in the form of gamma rays which are detected by



a special camera and a computer to create images of the inside of your body. Nuclear medicine imaging provides unique information that often cannot be obtained using other imaging procedures.

Tell your doctor if there's a possibility you are pregnant or if you are breastfeeding and discuss any recent illnesses, medical conditions, allergies and medications you're taking. Depending on the type of exam, your doctor will instruct you on what you may eat or drink beforehand, especially if sedation is to be used. Leave jewelry at home and wear loose, comfortable clothing. You may be asked to wear a gown.

What is Cardiac Nuclear Medicine?

Nuclear medicine is a branch of medical imaging that uses small amounts of radioactive material to diagnose and determine the severity of or treat a variety of diseases, including many types of cancers, heart disease, gastrointestinal, endocrine, neurological disorders and other abnormalities within the body. Because nuclear medicine procedures are able to pinpoint molecular activity within the body, they offer the potential to identify disease in its earliest stages as well as a patient's immediate response to therapeutic interventions.

Cardiac nuclear medicine is useful in diagnosing and assessing coronary artery disease. It is also used to evaluate cardiomyopathy and identify possible damage to the heart from chemotherapy or radiotherapy.

Nuclear medicine imaging procedures are noninvasive and, with the exception of intravenous injections, are usually painless medical tests that help physicians diagnose and evaluate medical conditions. These imaging scans use radioactive materials called radiopharmaceuticals or radiotracers.

Radiotracers are molecules linked to, or "labeled" with, a small amount of radioactive material that can be detected on the PET scan. They are designed to accumulate in cancerous tumors or regions of inflammation. They can also be made to bind to specific proteins in the body. The most commonly used radiotracer is F-18 fluorodeoxyglucose, or FDG, a molecule similar to glucose. Cancer cells may absorb glucose at a higher rate, being more metabolically active. This higher rate can be seen on PET scans, and that allows your doctor to identify disease before it may be seen on other imaging tests. FDG is just one of many radiotracers in use or in development for a variety of conditions throughout the body.

Depending on the type of nuclear medicine exam, the radiotracer is either injected into the body, swallowed or inhaled as a gas and eventually accumulates in the organ or area of the body being examined. Radioactive emissions from the radiotracer are detected by a special camera or imaging device that produces pictures and provides molecular information.

In many centers, nuclear medicine images can be superimposed with computed tomography (CT) or magnetic resonance imaging (MRI) to produce special views, a practice known as image fusion or co-registration. These views allow the information from two different exams to be correlated and interpreted on one image, leading to more precise information and accurate diagnoses. In addition, manufacturers are now making single photon emission computed tomography/computed tomography (SPECT/CT) and positron emission tomography/computed tomography (PET/CT) units that are able to perform both imaging exams at the same time. An emerging imaging technology, but not readily available at this time is PET/MRI.

Cardiac nuclear medicine exams provide pictures of the distribution of blood flow to the heart muscle and can be used to visualize the function of the heart.

What are some common uses of the procedure?

Physicians use cardiac nuclear medicine studies to help diagnose cardiac disease. The symptoms include:

- unexplained chest pain.
- chest pain brought on by exercise (called angina).
- shortness of breath with exertion.
- abnormal electrocardiogram.

Cardiac nuclear medicine imaging is also performed:

- to visualize blood flow patterns to the heart walls, called a myocardial perfusion scan.
- to evaluate the presence and extent of suspected or known coronary artery disease.
- to determine the extent of injury to the heart following a heart attack, or myocardial infarction.
- to evaluate the results of bypass surgery or other revascularization procedures designed to restore blood supply to the heart.
- in conjunction with an electrocardiogram (ECG), to evaluate heart-wall movement and overall heart function with a technique called cardiac gating.

How should I prepare?

You may be asked to wear a gown during the exam or you may be allowed to wear your own clothing.

Women should always inform their physician or technologist if there is any possibility that they are pregnant or if they are breastfeeding. See the Safety page for more information about pregnancy and breastfeeding related to nuclear medicine imaging.

You should inform your physician and the technologist performing your exam of any medications you are taking, including vitamins and herbal supplements. You should also inform them if you have any allergies and about recent illnesses or other medical conditions.

You should inform your physician if you are pregnant or breastfeeding and/or if you have:

- had a recent heart attack or myocardial infarction
- heart failure
- asthma
- chronic lung disease
- conduction abnormalities within the heart (such as AV block), aortic stenosis or other abnormalities with the valves of your heart
- any abnormality with the heart and lungs

Also, if you have problems with your knees, hips or keeping your balance, tell your doctor as this may limit your ability to perform the exercise needed for this procedure. You should wear comfortable clothing and walking shoes. Do not apply oil, lotion, or cream to your skin the day of the exam. If you use an inhaler for asthma or other breathing problems, bring it to the test and make sure the health care team monitoring your stress test knows that you use an inhaler.

Jewelry and other metallic accessories should be left at home if possible, or removed prior to the exam because they may interfere with the procedure.

You should avoid caffeine (caffeinated as well as decaffeinated coffee, hot and cold tea, caffeinated soft drinks, energy drinks, chocolate and medications containing caffeine, etc.) and smoking for up to 48 hours before your examination. Your physician or radiologist may give you more specific instructions.

You should not eat or drink anything after midnight on the day of your procedure, but you may continue taking medications with small amounts of water unless your physician says otherwise. If you take beta-blocker or calcium channel blocker medication (Inderal, metoprolol, Norvasc, etc.) you should specifically ask your physician about temporary discontinuation. If you are diabetic, check with your physician about specific instructions for your diabetes medication on the day of the exam.

What does the equipment look like?

The special camera and imaging techniques used in nuclear medicine include the gamma camera and single-photon emission-computed tomography (SPECT).

The gamma camera, also called a scintillation camera, detects radioactive energy that is emitted from the

patient's body and converts it into an image. The gamma camera itself does not emit any radiation. The gamma camera is composed of radiation detectors, called gamma camera heads, which are encased in metal and plastic and most often shaped like a box, attached to a round circular donut shaped gantry. The patient lies on the examination table which slides in between two parallel gamma camera heads that are positioned above the patient and beneath the examination table. Sometimes, the gamma camera heads are oriented at a 90 degree angle and placed over the patient's body.

SPECT involves the rotation of the gamma camera heads around the patient's body to produce more detailed, three-dimensional images.

Most nuclear medicine procedures use a gamma camera. Some nuclear medicine equipment has CT capabilities that help improve the images and increase the ability to combine functional imaging (nuclear medicine) and anatomic imaging (CT).

A computer aids in creating the images from the data obtained by the gamma camera.

How does the procedure work?

With ordinary x-ray examinations, an image is made by passing x-rays through the patient's body. In contrast, nuclear medicine procedures use a radioactive material, called a radiopharmaceutical or radiotracer, which is injected into the bloodstream, swallowed or inhaled as a gas. This radioactive material accumulates in the organ or area of your body being examined, where it gives off a small amount of energy in the form of gamma rays. Special cameras detect this energy, and with the help of a computer, create pictures offering details on both the structure and function of organs and tissues in your body.

In order to evaluate the coronary arteries, heart scans are often performed immediately after patients have engaged in physical exercise (called a stress test) so that blood flow throughout the heart is maximized, making any blockages of the coronary arteries easier to detect. These images of the heart are compared with heart images taken while the patient is at rest. Patients who are unable to exercise are given a drug that increases blood flow to the heart.

How is the procedure performed?

Nuclear medicine imaging is usually performed on an outpatient basis, but is often performed on hospitalized patients as well.

You will be positioned on an examination table. A nurse or technologist will insert an intravenous (IV) line into a vein in your hand or arm.

The exam will usually begin with an injection of tracer while you are resting. Within the first hour after the tracer is injected, you will lie on a moveable imaging table with your arms (or in some cases your left arm only) over your head for about 15 to 20 minutes while images are recorded. Following imaging, you will undergo a stress test, which requires you to exercise either by walking on a treadmill or pedaling a stationary bicycle for a few minutes. While you exercise, the electrical activity of your heart will be monitored by electrocardiography (ECG) and your blood pressure will be frequently measured. When

blood flow to the heart has reached its peak, you will be given the radiotracer through your IV. After you complete the stress test, you may be asked to drink some water. You will be placed on the imaging table a second time so a second series of images can be recorded. At this time, an ECG will also be placed to image the motion of your heart.

If you are unable to use a treadmill or bicycle, you will not exercise but you will be given a drug that will increase blood flow to the heart.

Actual scanning time for each heart scan varies from 15 to 30 minutes, depending on the type of scanner used. Total time in the nuclear medicine department will be approximately two to four hours.

If the SPECT scanner has CT capabilities, a short CT scan of your heart will be obtained. The CT may be obtained before or after each of the nuclear medicine imaging procedures. You will not have to get up or change positions on the table for this part of the exam as the CT is part of the nuclear medicine equipment, but you will be asked to stay very still for this portion of the exam.

When the examination is completed, you may be asked to wait until the technologist checks the images in case additional images are needed. Occasionally, more images are obtained for clarification or better visualization of certain areas or structures. The need for additional images does not necessarily mean there was a problem with the exam or that something abnormal was found, and should not be a cause of concern for you.

If you had an intravenous line inserted for the procedure, it will usually be removed unless you are scheduled for an additional procedure that same day that requires an intravenous line.

What will I experience during and after the procedure?

Except for intravenous injections, most nuclear medicine procedures are painless and are rarely associated with significant discomfort or side effects.

When the radiotracer is given intravenously, you will feel a slight pin prick when the needle is inserted into your vein for the intravenous line. When the radioactive material is injected into your arm, you may feel a cold sensation moving up your arm, but there are generally no other side effects.

You will be asked to exercise until you are either too tired to continue or short of breath, or if you experience chest pain, leg pain, or other discomfort that causes you to want to stop.

If you are given a medication to increase blood flow because you are unable to exercise, the medication may induce a brief period of feeling anxious, dizzy, nauseous, shaky or short of breath. Mild chest discomfort may also occur. Any symptoms that do develop typically resolve as soon as the infusion is complete. In rare instances, if the side effects of the medication are severe or make you too uncomfortable, other drugs can be given to stop the effects.

It is important that you remain still while the images are being recorded. Though nuclear imaging itself causes no pain, there may be some discomfort from having to remain still or to stay in one particular position during imaging.

Unless your physician tells you otherwise, you may resume your normal activities after your nuclear

medicine scan. If any special instructions are necessary, you will be informed by a technologist, nurse or physician before you leave the nuclear medicine department.

Through the natural process of radioactive decay, the small amount of radiotracer in your body will lose its radioactivity over time. It may also pass out of your body through your urine or stool during the first few hours or days following the test. You should also drink plenty of water to help flush the radioactive material out of your body as instructed by the nuclear medicine personnel.

Who interprets the results and how do I get them?

A radiologist or other physician who has specialized training in nuclear medicine will interpret the images and send a report to your referring physician.

What are the benefits vs. risks?

Benefits

- Nuclear medicine examinations provide unique information—including details on both function and anatomic structure of the body that is often unattainable using other imaging procedures.
- For many diseases, nuclear medicine scans yield the most useful information needed to make a diagnosis or to determine appropriate treatment, if any.
- A nuclear medicine scan is less expensive and may yield more precise information than exploratory surgery.

Risks

- If you have coronary artery disease, it is possible that you could experience chest pain during exercise or when a drug is given for the stress test. However, your heart will be monitored and if necessary, medication can be given for your chest pain.
- If life threatening cardiac disease is suspected because of the test findings, your cardiologist may consider same-day cardiovascular intervention.
- Because the doses of radiotracer administered are small, diagnostic nuclear medicine procedures result in relatively low radiation exposure to the patient, acceptable for diagnostic exams. Thus, the radiation risk is very low compared with the potential benefits.
- Nuclear medicine diagnostic procedures have been used for more than five decades, and there are no known long-term adverse effects from such low-dose exposure.
- The risks of the treatment are always weighed against the potential benefits for nuclear medicine therapeutic procedures. You will be informed of all significant risks prior to the treatment and have an opportunity to ask questions.
- Allergic reactions to radiopharmaceuticals may occur but are extremely rare and are usually mild. Nevertheless, you should inform the nuclear medicine personnel of any allergies you may have or other problems that may have occurred during a previous nuclear medicine exam.
- Injection of the radiotracer may cause slight pain and redness which should rapidly resolve.

- Women should always inform their physician or radiology technologist if there is any possibility that they are pregnant or if they are breastfeeding. See the Safety page for more information about pregnancy, breastfeeding and nuclear medicine exams.

What are the limitations of Cardiac Nuclear Medicine?

Nuclear medicine procedures can be time consuming. It can take several hours to days for the radiotracer to accumulate in the body part of interest and imaging may take up to several hours to perform, though in some cases, newer equipment is available that can substantially shorten the procedure time.

The resolution of structures of the body with nuclear medicine may not be as high as with other imaging techniques, such as CT or MRI. However, nuclear medicine scans are more sensitive than other techniques for a variety of indications, and the functional information gained from nuclear medicine exams is often unobtainable by other imaging techniques.

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