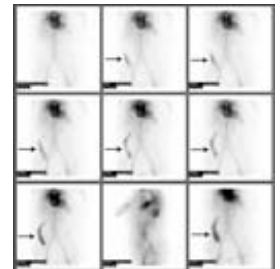




## General Nuclear Medicine

### What is General 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.



### Diagnosis

Nuclear medicine, or radionuclide, diagnostic 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.

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 detailed 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.

### Therapy

Nuclear medicine also offers therapeutic procedures, such as radioactive iodine (I-131) therapy that use small amounts of radioactive material to treat cancer and other medical conditions affecting the thyroid gland, as well as treatments for other cancers and medical conditions.

Non-Hodgkin's lymphoma patients who do not respond to chemotherapy may undergo radioimmunotherapy (RIT).

Radioimmunotherapy (RIT) is a personalized cancer treatment that combines radiation therapy with the

targeting ability of immunotherapy, a treatment that mimics cellular activity in the body's immune system.

## What are some common uses of the procedure?

Physicians use radionuclide imaging procedures to visualize the structure and function of an organ, tissue, bone or system within the body in order to:

### Cancer

- stage cancer by determining the presence or spread of cancer in various parts of the body
- localize sentinel lymph nodes before surgery in patients with breast cancer or melanoma
- plan treatment
- evaluate response to therapy
- detect the recurrence of cancer
- detect rare tumors of the pancreas and adrenal glands

### Renal

- analyze native and transplant kidney function
- detect urinary tract obstruction
- evaluate for hypertension related to the kidney arteries
- evaluate kidneys for infection versus scar



- evaluate and follow-up urinary reflux in pediatric patients

### Heart

- visualize heart blood flow and function (such as a myocardial perfusion scan)
- detect coronary artery disease and the extent of coronary stenosis
- assess damage to the heart following a heart attack
- evaluate treatment options such as bypass heart surgery and angioplasty
- evaluate the results of revascularization procedures
- detect heart transplant rejection
- evaluate heart function before and after chemotherapy (MUGA)

### Lungs

- scan lungs for respiratory and blood flow problems
- assess differential lung function for lung reduction or transplant surgery
- detect lung transplant rejection

### Bones

- evaluate bones for fractures, infection and arthritis
- evaluate for metastatic bone disease
- evaluate painful prosthetic joints
- evaluate bone tumors
- identify sites for biopsy

## **Brain**

- investigate abnormalities in the brain, such as seizures, memory loss and abnormalities in blood flow
- detect the early onset of neurological disorders such as Alzheimer disease
- plan surgery and localize seizure foci
- evaluate post-concussion syndrome

## **Other Systems**

- identify inflammation or abnormal function of the gallbladder
- identify bleeding into the bowel
- assess post operative complication of gallbladder surgery
- evaluate lymphedema
- evaluate fever of unknown origin
- locate the presence of infection
- measure thyroid function to detect an overactive or underactive thyroid
- help diagnose hyperthyroidism and blood cell disorders
- evaluate for hyperparathyroidism
- evaluate stomach emptying
- evaluate spinal fluid flow and potential spinal fluid leaks



## **In children, nuclear medicine is also used to:**

- investigate abnormalities in the esophagus, kidneys and intestines
- evaluate the openness of tear ducts and shunts in the brain and heart

## **Nuclear medicine therapies include:**

- Radioactive iodine (I-131) therapy used to treat some causes of hyperthyroidism (overactive thyroid gland, for example, Graves' disease) and thyroid cancer
- Radioactive antibodies used to treat certain forms of lymphoma (cancer of the lymphatic system)
- Radioactive phosphorus (P-32) used to treat certain blood disorders
- Radioactive materials used to treat painful tumor metastases to the bones
- I-131 MIBG (radioactive iodine laced with metaiodobenzylguanidine) used to treat adrenal gland tumors in adults and nerve tissue tumors in children

## 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 ([www.RadiologyInfo.org/en/safety/](http://www.RadiologyInfo.org/en/safety/)) 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.

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 will receive specific instructions based on the type of scan you are undergoing.

In some instances, certain medications or procedures may interfere with the examination ordered. See the Radioactive Iodine (I-131) Therapy page ([www.RadiologyInfo.org/en/info.cfm?pg=radioiodine](http://www.RadiologyInfo.org/en/info.cfm?pg=radioiodine)) for instructions on how to prepare for the procedure.

## What does the equipment look like?

Nuclear medicine procedures are performed using one of three systems: a gamma camera, single photon emission computed tomography (SPECT) or positron emission tomography (PET).

The gamma camera, which is encased in metal, is capable of detecting radiation and taking pictures from different angles. A gamma camera does not emit any radiation. It may be suspended over the examination table or it may be beneath the table. Often, gamma cameras are dual-headed with one camera next to the other at a 90 degree angle. In some imaging centers, the gamma camera is located beneath the exam table and out of view. The camera may be located within a large, doughnut-shaped scanner similar in appearance to a computed tomography (CT) scanner.



SPECT uses a gamma camera that rotates around the body to produce more detailed, three-dimensional images.

A PET scanner is a large machine with a round, doughnut shaped hole in the middle, similar to a CT or MRI unit. Within this machine are multiple rings of detectors that record the emission of energy from the radiotracer in your body.

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

A probe is a small hand-held device resembling a microphone that can detect and measure the amount of the radiotracer in a small area of your body.

There is no specialized equipment used during radioactive iodine therapy, but the technologist or other

personnel administering the treatment may cover your clothing and use lead containers to shield the radioactive material you will be receiving.

## How does the procedure work?

With ordinary x-ray examinations, an image is made by passing x-rays through the body from an outside source. In contrast, nuclear medicine procedures use a radioactive material called a radiopharmaceutical or radiotracer, which is injected into your 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. A gamma camera, PET scanner, or probe detects this energy and with the help of a computer creates pictures offering details on both the structure and function of organs and tissues in your body.

Unlike other imaging techniques, nuclear medicine imaging exams focus on depicting physiologic processes within the body, such as rates of metabolism or levels of various other chemical activity, instead of showing anatomy and structure. Areas of greater intensity, called "hot spots," indicate where large amounts of the radiotracer have accumulated and where there is a high level of chemical or metabolic activity. Less intense areas, or "cold spots," indicate a smaller concentration of radiotracer and less chemical activity.

In radioactive iodine (I-131) therapy, radioactive iodine (I-131) is swallowed, absorbed into the bloodstream in the gastrointestinal (GI) tract and concentrated from the blood by the thyroid gland where it destroys cells within that organ.

Radioimmunotherapy (RIT) is a combination of radiation therapy and immunotherapy. In immunotherapy, a laboratory-produced molecule called a monoclonal antibody is engineered to recognize and bind to the surface of cancer cells. Monoclonal antibodies mimic the antibodies naturally produced by the body's immune system that attack invading foreign substances, such as bacteria and viruses.

In RIT, a monoclonal antibody is paired with a radioactive material. When injected into the patient's bloodstream, the antibody travels to and binds to the cancer cells, allowing a high dose of radiation to be delivered directly to the tumor.

## 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. If necessary, a nurse or technologist will insert an intravenous (IV) line into a vein in your hand or arm.

Depending on the type of nuclear medicine exam you are undergoing, the dose of radiotracer is then injected intravenously, swallowed or inhaled as a gas.

It can take anywhere from several seconds to several days for the radiotracer to travel through your body and accumulate in the organ or area being studied. As a result, imaging may be done immediately, a few hours later, or even several days after you have received the radioactive material.

When it is time for the imaging to begin, the camera or scanner will take a series of images. The camera may rotate around you or it may stay in one position and you will be asked to change positions in between images. While the camera is taking pictures, you will need to remain still for brief periods of time. In some cases, the camera may move very close to your body. This is necessary to obtain the best quality images. If you are claustrophobic, you should inform the technologist before your exam begins.

If a probe is used, this small hand-held device will be passed over the area of the body being studied to measure levels of radioactivity. Other nuclear medicine tests measure radioactivity levels in blood, urine or breath.

The length of time for nuclear medicine procedures varies greatly, depending on the type of exam. Actual scanning time for nuclear imaging exams can take from 20 minutes to several hours and may be conducted over several days.

Young children may require gentle wrapping or sedation to help them hold still. If your doctor feels sedation is needed for your child, you will receive specific instructions regarding when and if you can feed your child on the day of the exam. A physician or nurse specializing in the administration of sedation to children will be available during the exam to ensure your child's safety while under the effects of sedation.

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.

During radioactive iodine (I-131) therapy, which is most often an outpatient procedure, the radioactive iodine is swallowed, either in capsule or liquid form.

Radioimmunotherapy (RIT), also typically an outpatient procedure, is delivered through injection.

## **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.

When swallowed, the radiotracer has little or no taste. When inhaled, you should feel no differently than when breathing room air or holding your breath.

With some procedures, a catheter may be placed into your bladder, which may cause temporary discomfort.

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.

See "Safety in Nuclear Medicine Procedures" ([www.radiologyinfo.org/en/safety/index.cfm?pg=sfty\\_xray#part7](http://www.radiologyinfo.org/en/safety/index.cfm?pg=sfty_xray#part7)) for more information.

You will be informed as to how often and when you will need to return to the nuclear medicine department for further procedures.

See the Radioactive iodine (I-131) Therapy page ([www.RadiologyInfo.org/en/info.cfm?pg=radioiodine](http://www.RadiologyInfo.org/en/info.cfm?pg=radioiodine)) for information regarding the side-effects of this treatment.

## 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 forward a report to your referring physician.

## What are the benefits vs. risks?

### Benefits

- Nuclear medicine examinations offer information that is unique—including details on both function and structure—and 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.
- Nuclear medicine is less expensive and may yield more precise information than exploratory surgery.
- Nuclear medicine offers the potential to identify disease in its earliest stage, often before symptoms occur or abnormalities can be detected with other diagnostic tests.
- By detecting whether lesions are likely benign or malignant, PET scans may eliminate the need for surgical biopsy or identify the best biopsy location.

### Risks

- Because the doses of radiotracer administered are small, diagnostic nuclear medicine procedures result in low radiation exposure, 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 ([www.RadiologyInfo.org/en/safety/](http://www.RadiologyInfo.org/en/safety/)) for more information about pregnancy, breastfeeding and nuclear medicine exams.

## What are the limitations of General Nuclear Medicine?

Nuclear medicine procedures can be time consuming. It can take hours to days for the radiotracer to accumulate in the part of the body under study 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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