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# Positron Emission Tomography - Computed Tomography (PET/CT) Scanning

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*This information is reviewed by a physician with expertise in the area presented and is further reviewed by committees from the American College of Radiology (ACR) and the Radiological Society of North America (RSNA), comprising physicians with expertise in several radiologic areas.*

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## What is Positron Emission Tomography – Computed Tomography (PET/CT) Scanning?

Positron emission tomography, also called PET imaging or a PET scan, is a type of nuclear medicine imaging.

Nuclear medicine is a branch of medical imaging that uses small amounts of radioactive material to diagnose or treat a variety of diseases, including many types of cancers, heart disease and certain other abnormalities within the body.

Nuclear medicine or radionuclide imaging procedures are noninvasive and usually painless medical tests that help physicians diagnose medical conditions. These imaging scans use radioactive materials called radiopharmaceuticals or radiotracers.

Depending on the type of nuclear medicine exam you are undergoing, the radiotracer is either injected into a vein, swallowed or inhaled as a gas and eventually accumulates in the organ or area of your body being examined, where it gives off energy in the form of gamma rays. This energy is detected by a device called a gamma camera, a (positron emission tomography) PET scanner and/or probe. These devices work together with a computer to measure the amount of radiotracer absorbed by your body and to produce special pictures offering details on both the structure and function of organs and tissues.

In some 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 studies 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 studies at the same time.

A PET scan measures important body functions, such as blood flow, oxygen use, and sugar (glucose) metabolism, to help doctors evaluate how well organs and tissues are functioning.

CT imaging uses special x-ray equipment, and in some cases a contrast material, to produce multiple images or pictures of the inside of the body. These images can then be interpreted by a radiologist on a computer monitor as printed images. CT imaging provides excellent anatomic information.

Today, most PET scans are performed on instruments that are combined PET and CT scanners. The combined PET/CT scans provide images that pinpoint the location of abnormal metabolic activity within the body. The combined scans have been shown to provide more accurate diagnoses than the two scans performed separately.

## What are some common uses of the procedure?

PET and PET/CT scans are performed to:

- detect cancer.
- determine whether a cancer has spread in the body.
- assess the effectiveness of a treatment plan, such as cancer therapy.
- determine if a cancer has returned after treatment.
- determine blood flow to the heart muscle.
- determine the effects of a heart attack, or myocardial infarction, on areas of the heart.
- identify areas of the heart muscle that would benefit from a procedure such as angioplasty or coronary artery bypass surgery (in combination with a myocardial perfusion scan).
- evaluate brain abnormalities, such as tumors, memory disorders and seizures and other central nervous system disorders.
- to map normal human brain and heart function.

## How should I prepare?

For a PET and PET/CT scan:

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 their baby.

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 will receive specific instructions based on the type of PET scan you are undergoing. Diabetic patients will receive special instructions to prepare for this exam.

If you are breastfeeding at the time of the exam, you should ask your radiologist how to proceed. It may help to pump breast milk ahead of time and keep it on hand for use after the PET radiopharmaceutical and CT contrast material are no longer in your body.

Metal objects including jewelry, eyeglasses, dentures and hairpins may affect the CT images and should be left at home or removed prior to your exam. You may also be asked to remove hearing aids and removable dental work.

Generally, you will be asked not to eat anything for several hours before a whole body PET/CT scan since eating may alter the distribution of the PET tracer in your body and can lead to a suboptimal scan. This could require the scan to be repeated on another day, so following instructions regarding eating is very important. You should not drink any liquids containing sugars or calories for several hours before the scan. Instead, you are encouraged to drink water. If you are diabetic, you may be given special instructions. You should inform your physician of any medications you are taking and if you have any allergies, especially to contrast materials, iodine, or seafood.

You will be asked and checked for any conditions that you may have that may increase the risk of using intravenous contrast material.

## What does the equipment look like?



A positron emission tomography (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.

The CT scanner is typically a large, box like machine with a hole, or short tunnel, in the center. You will lie on a narrow examination table that slides into and out of this tunnel. Rotating around you, the x-ray tube and electronic x-ray detectors are located opposite each other in a ring, called a gantry. The computer workstation that processes the imaging information is located in a separate room, where the technologist operates the scanner and monitors your examination.

Combined PET/CT scanners are combinations of both scanners and look similar to both the PET and CT scanners.

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

## How does the procedure work?

With ordinary x-ray examinations, an image is made by passing x-rays through your 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 studies are less directed toward picturing anatomy and structure, and more concerned with depicting physiologic processes within the body, such as rates of metabolism or levels of various other chemical activity. 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 activity. Less intense areas, or “cold spots,” indicate a smaller concentration of radiotracer and less chemical activity.

## 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 will take approximately 60 minutes for the radiotracer to travel through your body and to be absorbed by the organ or tissue being studied. You will be asked to rest quietly, avoiding movement and talking.

You may be asked to drink some contrast material that will localize in the intestines and help the radiologist interpreting the study.

You will then be moved into the PET/CT scanner and the imaging will begin.

You will need to remain still during imaging. The CT exam will be done first, followed by the PET scan. The actual CT scanning takes less than two minutes. The PET scan takes 20-30 minutes.

Total scanning time is approximately 30 minutes.

Depending on which organ or tissue is being examined, additional tests involving other tracers or drugs may be used, which could lengthen the procedure time to three hours. For example, if you are being examined for heart disease, you may undergo a PET scan both before and after exercising or before and after receiving intravenous medication that increases blood flow to the heart.

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. You will not be exposed to more radiation during this process.

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

## What will I experience during and after the procedure?

Most nuclear medicine procedures are painless and are rarely associated with significant discomfort or side effects.

If 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.

If you are claustrophobic, you may feel some anxiety while you are being scanned.

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 may be instructed to take special precautions after urinating, to flush the toilet twice and to wash your hands thoroughly.

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 who has specialized training in nuclear medicine will interpret the images and forward a report to your referring physician.

If your physician has ordered a diagnostic CT, a radiologist with specialized training in interpreting CT exams will report the findings of the CT and forward a report to your referring physician.

## What are the benefits vs. risks?

### Benefits

- The information provided by nuclear medicine examinations is unique 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.
- By identifying changes in the body at the cellular level, PET imaging may detect the early onset of disease before it is evident on other imaging tests such as CT or MRI.

The benefits of a combined PET/CT scanner include:

- greater detail with a higher level of accuracy; because both scans are performed at one time without the patient having to change positions, there is less room for error.

- greater convenience for the patient who undergoes two exams (CT & PET) at one sitting, rather than at two different times.

### 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.
- 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 their baby.

## What are the limitations of Positron Emission Tomography?

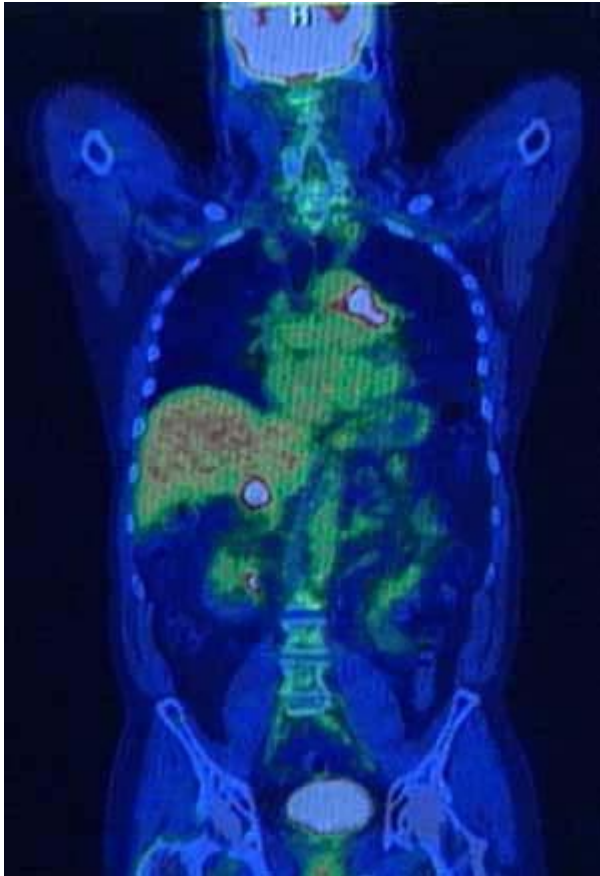
Nuclear medicine procedures can be time-consuming. It can take hours to days for the radiotracer to accumulate in the part of the body under study and imaging may take up to several hours to perform, though in some cases, newer equipment is available that can substantially shorten the procedure time. You will be informed as to how often and when you will need to return to the nuclear medicine department for further procedures.

The resolution of structures of the body with nuclear medicine may not be as clear 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 any other imaging techniques.

PET scanning can give false results if chemical balances within the body are not normal. Specifically, test results of diabetic patients or patients who have eaten within a few hours prior to the examination can be adversely affected because of altered blood sugar or blood insulin levels.

Because the radioactive substance decays quickly and is effective for only a short period of time, it is important for the patient to be on time for the appointment and to receive the radioactive material at the scheduled time. Thus, late arrival for an appointment may require rescheduling the procedure for another day.

A person who is very obese may not fit into the opening of a conventional PET/CT unit.



*Sample image obtained using a combination of PET and CT imaging technology.*

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