

Nuclear Medicine and Radiation Safety

What is radiation?

Radiation is simply a type of energy. The most familiar form of radiation is visible light, like that produced from the sun or a light bulb. Other forms of radiation, such as X-rays and gamma rays, are used in a number of beneficial ways, including medicine.

Natural radiation exposure comes from the earth in rocks and soil and from outer space in the form of cosmic rays. A small amount of radioactive material even exists naturally in our bodies. Every year, each person is exposed to this natural radiation and radiation from a variety of other sources, including household smoke detectors and color television sets. Air travel increases exposure to cosmic radiation due to the higher altitudes and less atmospheric shielding.

Naturally occurring background radiation and modern activities such as watching TV and flying in an airplane all contribute to a lifetime exposure that is only slightly increased by medical imaging. Because natural radiation is always present in everyday life, it is impossible to be totally shielded from it. On an annual basis, every person is exposed to a variable amount of radiation from natural sources, such as cosmic rays, and from industrial sources. There is no proven additional risk to human beings from background radiation exposure.

How can radiation be of value?

Radiation used for medical purposes has value for patients in diagnosing and treating disease. The treating physician should explain the benefit of a procedure and the risks associated with not undergoing the diagnostic or therapeutic procedure.

The risk is very different from one patient to another, even for the same diagnostic or therapeutic procedure, and even though the amount of exposure is the same. For example, different patients and different body parts and tissues react differently to radiation. The same test ordered in two different patients with similar but not exactly the same disease may have a different risk profile. Age also plays a role in any risk associated with medical radiation. Risks associated with any medical radiation exposure are based on a variety of factors and a medical evaluation and not on any mathematical number.

What is molecular imaging and nuclear medicine?

Molecular imaging procedures are noninvasive and very safe. More than 20 million Americans benefit each year from nuclear medicine procedures used to diagnose and treat a wide variety of diseases.

Of the molecular imaging techniques in use today, nuclear medicine procedures, such as PET scans and I-131 radiotherapy, use small amounts of radioactive materials, called radiopharmaceuticals or radiotracers, to diagnose and treat disease.

In general, the radiation risk involved in these procedures is very low compared with the potential benefits. There are no known long-term adverse side effects from diagnostic nuclear medicine procedures, which have been performed for more than 50 years. Allergic reactions may occur but are extremely rare and usually mild.

How can radiopharmaceuticals benefit the medical care of patients?

Radiopharmaceuticals are used to diagnose and treat a variety of diseases ranging from cancer to dementia and noncancerous disorders such as broken bones. Radiation exposure to patients is usually minimal for most diagnostic scans and slightly higher when being used as therapies. This is because diagnostic imaging uses a low-energy radiation to see the target organ on the scan, while the therapy requires a higher energy radiation to target and kill the abnormal cell.

Radiopharmaceuticals can save lives and improve a patient's quality of life by providing diagnostic information crucial for appropriate medical care or delivering a much needed therapy. This benefit is usually discussed with the treating doctor as to how a nuclear medicine procedure can help the patient's medical care.

How are radiopharmaceuticals used?

In a nuclear medicine imaging scan, each radiotracer is attracted to specific organs, bones, or tissues. A special camera (PET, SPECT or gamma camera) takes pictures of the distribution of the radiopharmaceutical in the body. The use of radiation in these procedures offers a safe and cost-effective means to provide doctors with diagnostic information that would otherwise require exploratory surgery, necessitate more costly and invasive procedures, or simply be unavailable.

Radiopharmaceuticals are also used for therapy, to treat overactive thyroids and some cancers. Radiopharmaceuticals are approved by the US Food and Drug Administration (FDA), tested carefully prior to general use and prepared with great care.

How much radiation exposure is involved in nuclear medicine procedures?

Because the amount of radiotracer used in nuclear medicine scans is extremely small, the patient's radiation exposure is small. Nuclear medicine specialists use the ALARA principle (As Low As Reasonably Achievable) to carefully select the amount of radiopharmaceutical that will provide an accurate test with the least amount of radiation exposure to the patient. The actual dosage is determined by the patient's body weight, the reason for the study and the body part being imaged. The targeted nature of radiopharmaceuticals allows them to be delivered mostly to the organ of interest while maintaining a low whole body radiation exposure.

How do nuclear medicine procedures compare with X-rays and CT scans?

Nuclear medicine tests and other imaging technologies differ in the way they use radiation to obtain pictures of the body. Nuclear medicine scans detect the radiation coming from a radioactive material inside a patient's body. In contrast, other imaging procedures (for example, X-ray and computed tomography or CT scan) obtain images by using machines that send radiation through the body.

Nuclear medicine is also different from other imaging procedures in that it determines the presence of disease based on biological changes in tissue rather than changes in anatomy.

One of the most commonly used nuclear medicine exams, the PET scan, is often performed in conjunction with computed tomography (CT) because the combined images provide physicians with both functional and anatomical information of the body.

How should I prepare for a nuclear medicine procedure?

Your physician or healthcare facility should provide you with information on how to prepare for your specific nuclear medicine procedure as well as safety and home care instructions following the procedure. Patient fact sheets provide additional information on individual procedures.

Radiotracers have very short physical half-lives, which means they decay quickly into non-radioactive forms. However, radiation detection devices used at airports and federal buildings may be sensitive to the radiation levels present in patients who have recently had nuclear medicine procedures.

Are nuclear medicine studies safe for children?

Nuclear medicine studies have been performed on babies and children of all ages for more than 40 years without any known adverse effects. The functional information about the body obtained from these exams and the low doses of radiation used make it a safe and effective diagnostic tool in children.

Are nuclear medicine studies safe for pregnant women?

Women who are or who might be pregnant and who are breastfeeding a child should tell their physician or technologist prior to having a nuclear medicine procedure so that medical care can be planned for both the mother and her baby. Some of the pharmaceuticals used in nuclear medicine procedures may pass into a breast-feeding mother's milk and subsequently to the child. To avoid this possibility, it is important that a nursing mother informs her physician and the nuclear medicine technologist before the examination begins.

Radiation emission guidelines

The following guidelines indicate how long patients may emit detectable radiation following treatment:

Diagnostic Tests

- Diagnostic nuclear medicine studies performed with Tc-99m (technetium-99m) should not be detectable—even by sensitive radiation monitors—three or four days after a test.
- Fluorine-18 (F-18), attached to glucose (FDG), is the most common radiopharmaceutical used with PET imaging. When used, it should be undetectable one day after a test.
- Fluorine-18 (F-18), when used in prostate cancer imaging either designed to attach to prostate specific membrane antigen (PSMA) on prostate cancer cells, or as an amino acid synthesis tracer for detection of prostate cancer. When used, it should be undetectable one day after a test. More information on PSMA imaging can be found at, [PSMA PET Scan](#) and [18F-Fluciclovine \[Axumin®\] PET/CT Scan](#)
- Myocardial perfusion (blood flow) imaging can be performed with technetium-99m (Tc-99m) sestamibi, technetium-99m tetrofosmin, thallium-201 (Tl-201) or a combination of both. While Tc-99m is undetectable after only a few days, Tl-201 may remain detectable for 30 days, e.g. attached to Octreotide or PSMA.

- Gallium-68, usually attached to octreotide (DOTATATE), is a PET imaging radiopharmaceutical used for the detection of well-differentiated neuroendocrine tumors. When used, it should be undetectable one day after a test.
- Copper-64 (Cu-64), usually attached to octreotide (DOTATATE) is a PET imaging radiopharmaceutical used for the detection of well-differentiated neuroendocrine tumors. When used, it should be undetectable five days after a test.
- MIBG imaging is used to detect tumors that come from hormone-producing neuroendocrine cells. More information is available at, [MIBG Scintigraphy](#)

Treatment or Therapy

- Radiiodine-131 (sodium I-131), used to treat hyperthyroidism, thyroid cancer and lymphoma, may remain detectable for as long as three months after treatment. More information on I-131 treatment is available at, [I-131 Radiotherapy](#)
- MIBG radionuclide therapy is a radioactive cancer therapy being used to treat certain neuroendocrine tumors, including neuroblastoma, pheochromocytoma, and paraganglioma. More information is available at, [I-131 MIBG Therapy](#)
- Lutetium-177 (¹⁷⁷Lu-DOTATATE) is used to treat neuroendocrine tumors. Usually, the amount of emitted radiation is low. However, it may be detectable for up to two months.
- ¹⁷⁷Lu PSMA-617 (Pluvicto) is used to treat hormone-resistant metastatic prostate cancer. More information is available at, [¹⁷⁷Lu PSMA-617](#)

Patients who plan to travel following a nuclear medicine therapy procedure should request a letter of explanation from their doctor that includes the patient's name, contact information for the testing facility, the name of the nuclear medicine procedure, the date of the treatment or test, the radioactive material that was used, its half-life, its administered activity and 24-hour contact information.

For additional information on travel after receiving ¹⁷⁷Lu-DOTATATE therapy go to, [Patient Travel Concerns After Treatment with ¹⁷⁷Lu-DOTATATE | Journal of Nuclear Medicine \(snmjournals.org\)](#)

Nuclear medicine procedures expose children to a very small amount of radiation that is within the lower range of what is received from routine diagnostic imaging procedures using X-rays. The specific amount of radiation exposure varies depending on the type of study.

Questions to ask your Doctor

- What is this test looking at?
- How will the results be used?
- How will this test help you help me?

Remember to always discuss your medical care with your doctor.

About SNMMI

The Society of Nuclear Medicine (SNMMI) is an international scientific and medical organization dedicated to raising public awareness about nuclear and molecular imaging and therapy and how they can help provide patients with the best health care possible. With more than 18,000 members, SNMMI has been a leader in unifying, advancing and optimizing nuclear medicine and molecular imaging since 1954.

The material presented in this pamphlet is for informational purposes only and is not intended as a substitute for discussions between you and your physician. Be sure to consult with your physician or the nuclear medicine department where the treatment will be performed if you want more information about this or other nuclear medicine procedures.