Real World Connections Nuclear Chemistry
Hannah

How Nuclear Medicine Works

In hospitals or on TV, you've probably seen patients undergoing radiation therapy for cancer, and doctors ordering PET scans to diagnose patients. These are part of the medical specialty called **nuclear medicine**. Nuclear medicine uses radioactive substances to image the body and treat disease. It looks at both the physiology (functioning) and the anatomy of the body in establishing diagnosis and treatment.

In this article, we will explain some of the techniques and terms used in nuclear medicine. You'll learn how radiation helps doctors see deeper inside the human body than they ever could.

Imaging in Nuclear Medicine

One problem with the human body is that it is opaque, and looking inside is generally painful. In the past, exploratory surgery was one common way to look inside the body, but today doctors can use a huge array of **non-invasive** techniques. Some of these techniques include things like X-rays, MRI scanners, CAT scans, ultrasound and so on. Each of these techniques has advantages and disadvantages that make them useful for different conditions and different parts of the body.

Nuclear medicine imaging techniques give doctors another way to look inside the human body. The techniques combine the use of computers, detectors, and radioactive substances. These techniques include:

- Positron emission tomography (PET)
- Single photon emission computed tomography (SPECT)
- Cardiovascular imaging
- Bone scanning

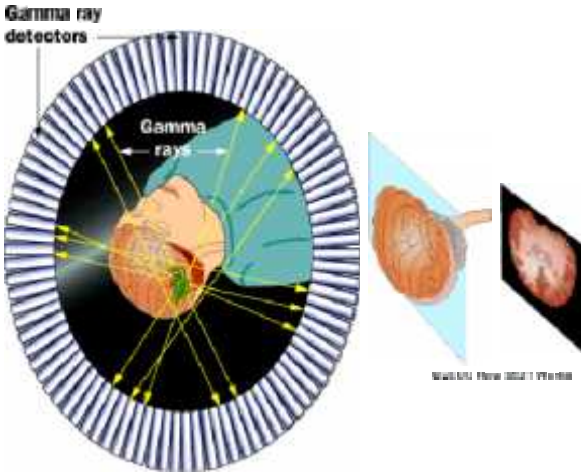
All of these techniques use different properties of radioactive elements to create an image. Nuclear medicine imaging is useful for detecting:

- tumors
- aneurysms (weak spots in blood vessel walls)
- irregular or inadequate blood flow to various tissues
- blood cell disorders and inadequate functioning of organs, such as thyroid and pulmonary function deficiencies.

The use of any specific test, or combination of tests, depends upon the patient's symptoms and the disease being diagnosed.

Positron Emission Tomography (PET)

PET produces images of the body by detecting the radiation emitted from radioactive substances. These substances are injected into the body, and are usually tagged with a radioactive atom, such as Carbon-11, Fluorine-18, Oxygen-15, or Nitrogen-13, that has a short decay time. These radioactive atoms are formed by bombarding normal chemicals with neutrons to create short-lived radioactive isotopes. PET detects the gamma rays given off at the site where a positron emitted from the radioactive substance collides with an electron in the tissue.



Cardiovascular Imaging Techniques

Cardiovascular imaging techniques use radioactive substances to chart the flow of blood through the heart and blood vessels. One example of a cardiovascular imaging technique is a **stress thallium test**, in which the patient is injected with a radioactive thallium compound, exercised on a treadmill, and imaged with a gamma ray camera. After a period of rest, the study is repeated without the exercise. The images before and after exercising are compared to reveal changes in blood flow to the working heart. These techniques are useful in detecting blocked arteries or arterioles in the heart and other tissues.

Treatment in Nuclear Medicine

In nuclear medicine imaging tests, injected radioactive substances do not harm the body. The radioisotopes used in nuclear medicine decay quickly, in minutes to hours, have lower radiation levels than a typical X-ray or CT scan, and are eliminated in the urine or bowel movement. But some cells are severely affected by ionizing radiation -- alpha, beta, gamma and X-rays. Cells multiply at different rates, and the quickly multiplying cells are affected more strongly than standard cells because of two properties:

- Cells have a mechanism that is able to repair damaged DNA.
- If a cell detects that its DNA is damaged while it is dividing, it will self-destruct.

Quickly multiplying cells have less time for the repair mechanism to detect and fix DNA errors before they divide, so they are more likely to self-destruct when corrupted by nuclear radiation. Since many forms of cancer are characterized by rapidly dividing cells, they can sometimes be treated with radiation therapy. Typically, radioactive wires or vials are placed near or around the tumor. For deep tumors, or tumors in inoperable places, high-intensity X-rays are focused on the tumor.

The problem with this sort of treatment is that normal cells that happen to reproduce quickly can be affected along with the abnormal cells. Hair cells, cells lining the stomach and intestines, skin cells and blood cells all happen to reproduce quickly, so they are strongly affected by radiation. This helps explain why people undergoing treatment for cancer frequently suffer hair loss and nausea.

Nuclear materials are also used to create radioactive tracers that can be injected into the bloodstream. One form of tracer flows in the blood, and allows the structure of the blood vessels to be viewed. This form of observation allows clots and other blood vessel abnormalities to be easily detected. Also, certain organs in the body concentrate certain types of chemicals -- the thyroid gland concentrates iodine, so by injecting radioactive iodine into the bloodstream, certain thyroid tumors can be detected. Similarly, cancerous tumors concentrate phosphates. By injecting the radioactive phosphorus-32 isotope into the bloodstream, tumors can be detected by their increased radioactivity.