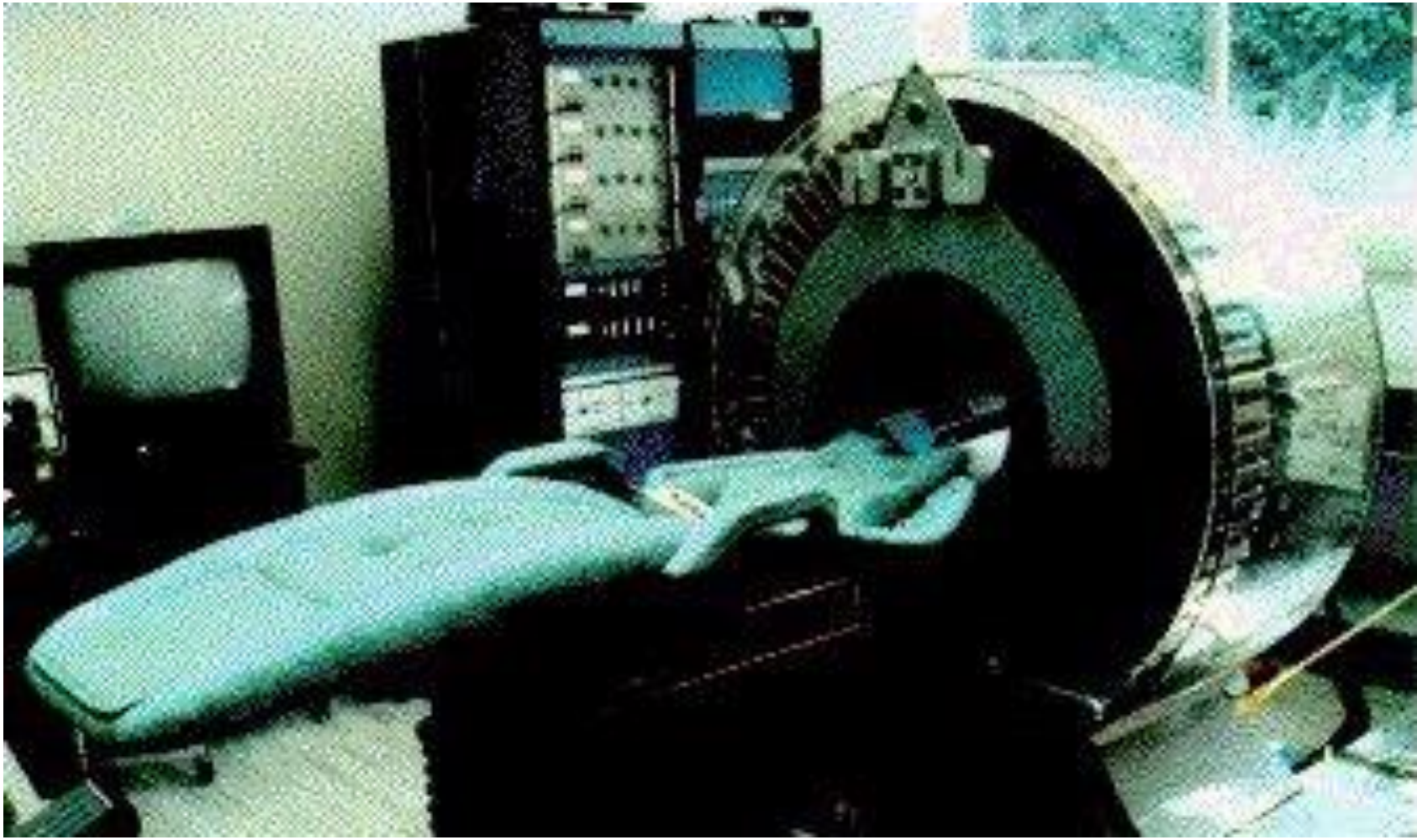
جامعة الانبار
كلية العلوم التطبيقية – هيت
قسم الفيزياء الحياتية

الاجهزة الطبية

Positron Emission Tomography (P.E.T)

Mohammed Qasim Taha

Positron Emission Tomography (P.E.T)



What is PET

- PET is a noninvasive, diagnostic imaging technique for measuring the metabolic activity of cells in the human body.
- It was developed in the mid 1970s and it was the first scanning method to give functional information about the brain.

What are some of the uses for PET

- Patients with conditions affecting the brain
- Heart
- Certain types of Cancer
- Alzheimer’s disease
- Some neurological disorders

A little history about the positron

- Existence first postulated in 1928 by Paul Dirac
- First observed in 1932 by Carl D. Anderson, who gave the positron its name. He also suggested to rename the electron to “negatron” but he was unsuccessful.

What happens after the positron is obtained?

- Left over Kinetic energy from the nuclear decay process is shared between the positron and the departing neutrino.
- Positron begins its activity in colliding with other particles and gradually losing its kinetic energy and thus slowing down.

What is a Positron?

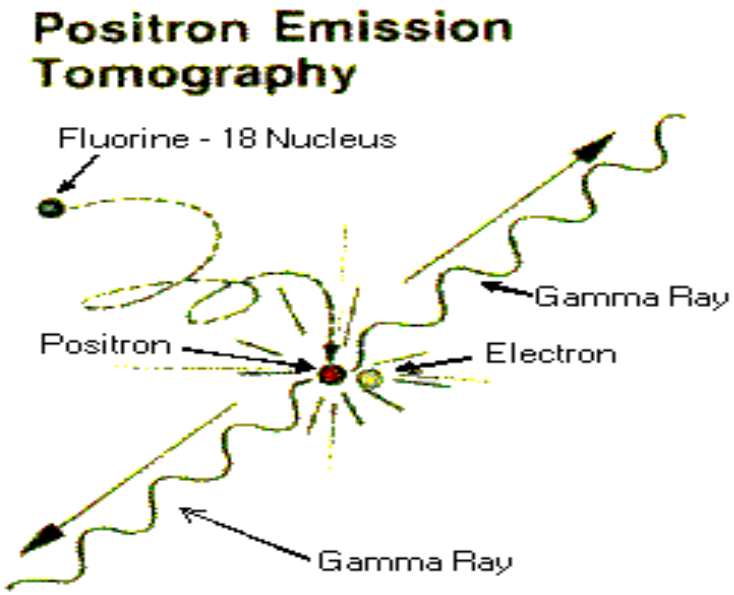
- A Positron is an anti-matter electron, it is identical in mass but has an apposite charge of +1.
- Positron can come from different number of sources, but for PET it is produced by nuclear decay.
- Nuclear decay is basically when unstable nuclei are produced in a cyclotron by bombarding the target material with protons (hydrogen ions), and as a result a neutron is released.
- proton (+1 charge) => neutron (0 charge) + positron (+1 charge) + neutrino (0 charge)

- After decay of Oxygen, we're left with 18-O fluorine-18

Annihilation of a positron and electron

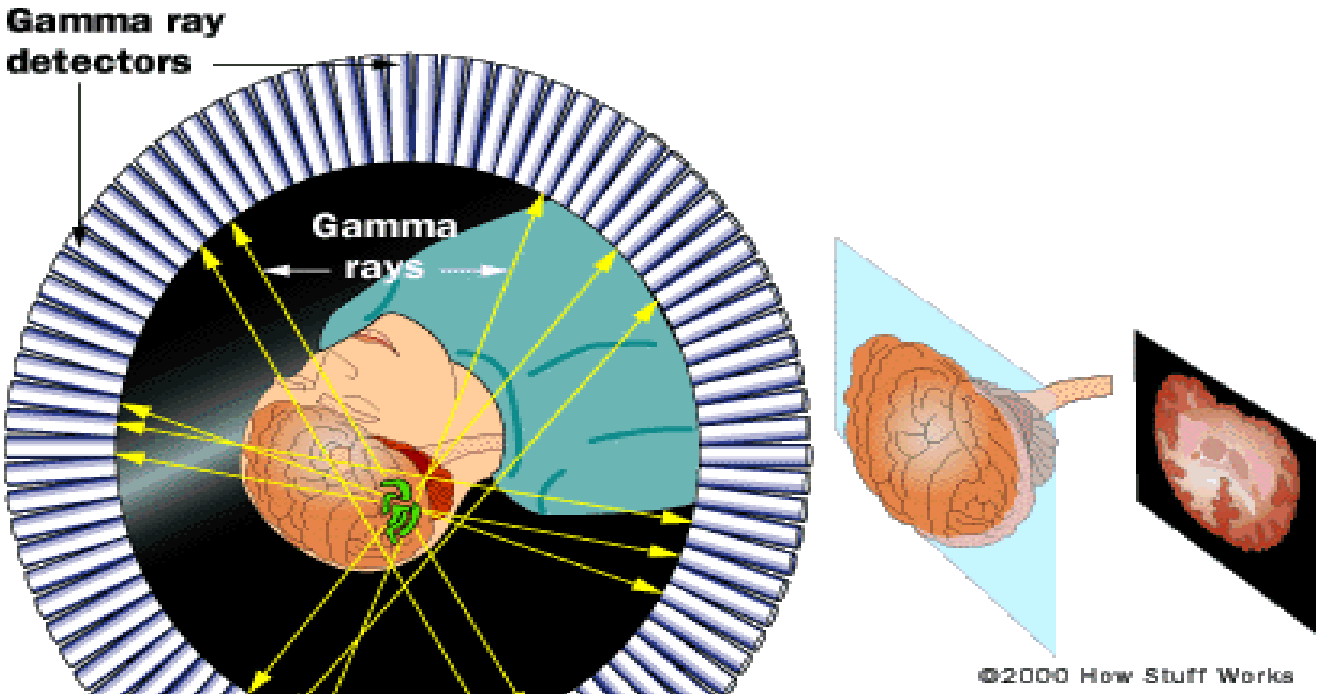
- The positron will encounter an electron and completely annihilate each other resulting in converting all their masses into energy. This is the result of two photons, or gamma rays.

- Because of conservation of energy and momentum, each photon has energy of 511keV and head in an almost 180 degrees from each other.
- 511keV is the ideal rest state annihilation value.



How do we detect photons (gamma rays)?

- PET detects these photons with a PET camera which allows to determine where they came from, where the nucleus was, when it decayed, and also knowing where the nucleus goes in the body.

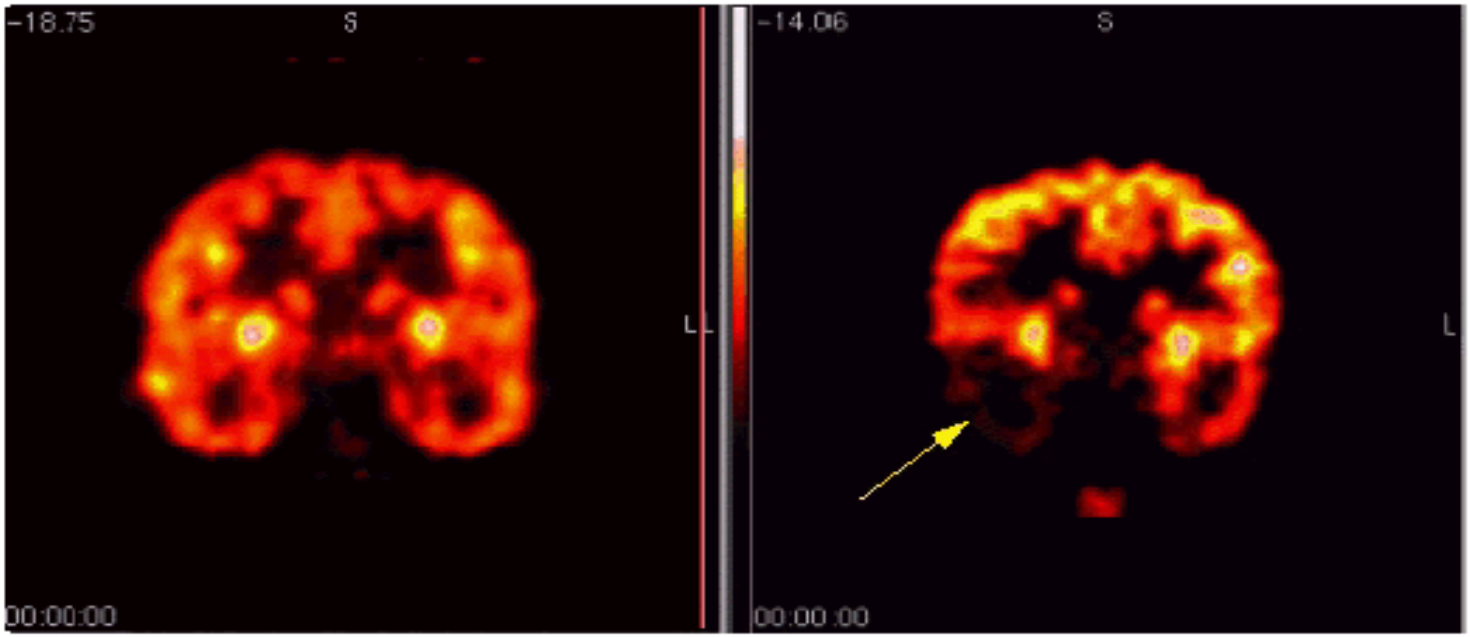


Cancer Patients

- Used to determine if there are new or advancing cancers by analysis of biochemical changes.
- It is used to examine the effects of cancer therapy by characterizing biochemical changes in the cancer. PET scans can be performed on the whole body.

Patients with brain disorders

- PET scans of the brain are used to evaluate patients who have memory disorders of an undetermined cause, suspected or proven brain tumors or seizure disorders that are not responsive to medical therapy and are therefore candidates for surgery.



Normal brain

Image of the brain of a 9-year-old female with a history of seizures poorly controlled by medication. PET imaging identifies the area (indicated by the arrow) of the brain responsible for the seizures. Through surgical removal of this area of the brain, the patient is rendered "seizure-free".

Alzheimer's disease

- With Alzheimer's disease there is no gross structural abnormality, but PET is able to show a biochemical change.

Heart Conditions

- PET scans of the heart are used to determine **blood flow to the heart muscle** and help evaluate **signs of coronary artery** الشريان التاجي **disease**.

- PET scans of the heart can also be used to **determine if areas of the heart that show decreased function are alive rather than scarred as a result of a prior heart attack**, called **a myocardial infarction** احتشاء عضلة القلب.

- Combined with a myocardial perfusion study, PET scans allow differentiation of nonfunctioning heart muscle from heart muscle that would benefit from a procedure, such as coronary bypass for instance.

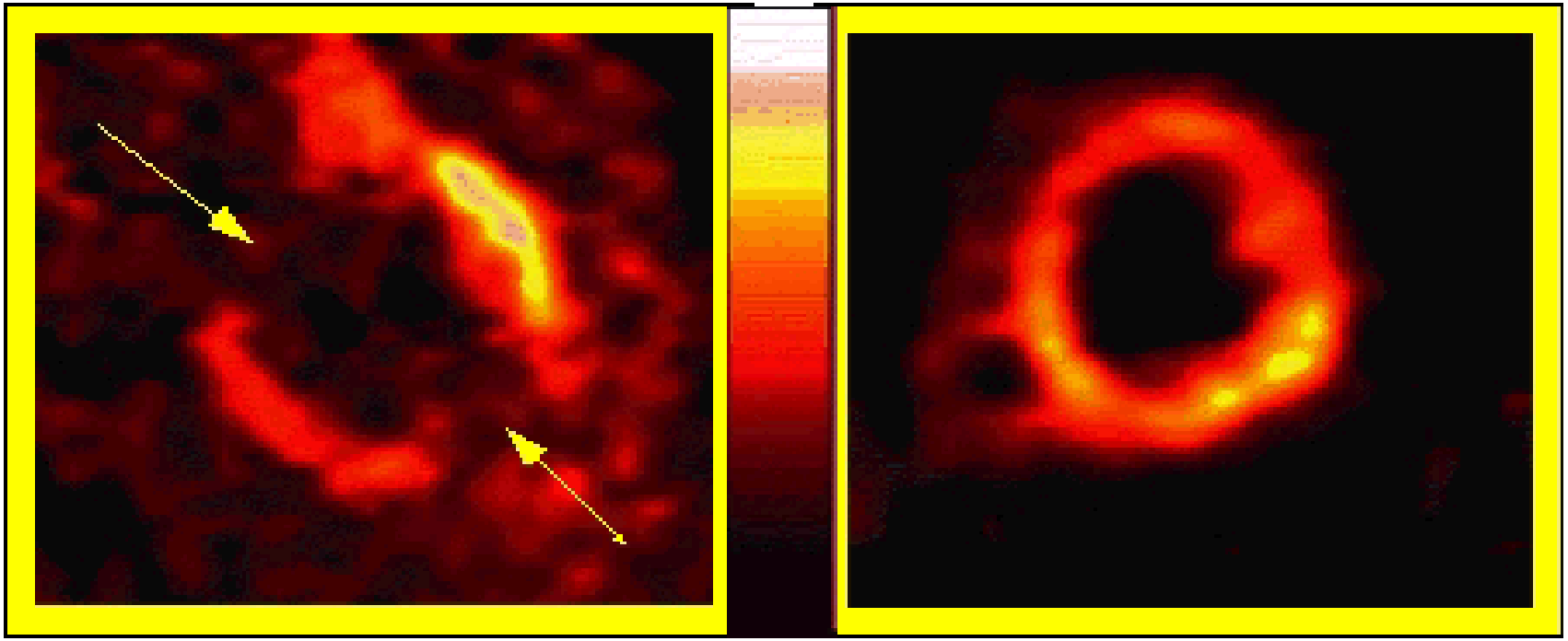


Image of heart which has had a mycardial infarction (heart attack). The arrow points to areas that have been damaged by the attack, indicating "dead" myocardial tissue. Therefore, the patient will not benefit from heart surgery, but may have other forms of treatment prescribed.

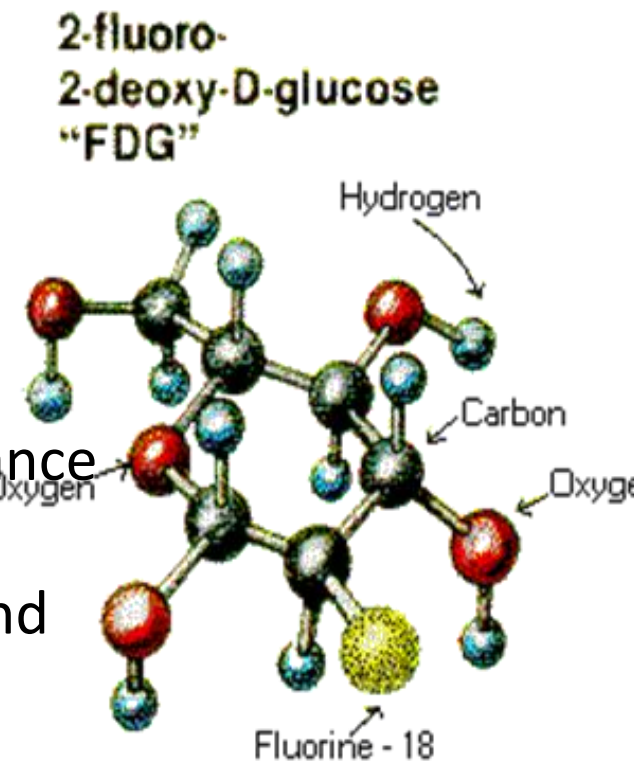
Normal heart

Neurological disorders

- Positron emission tomography (PET) imaging has recently been shown to aid in the diagnosis of particular neurological syndromes associated with cancer.
- Before their cancer is even diagnosed, patients can develop problems with the brain, spinal cord or nerves, though the cancer has not spread to the nervous system. Called "paraneoplastic neurological disorders," these neurological problems occur as the body's immune system begins to fight the cancer cells, but accidentally attacks the brain or nerves as well. These problems are uncommon, difficult to diagnose, and usually appear in patients whose primary cancer is extremely difficult to find. Abnormal antibodies in the blood or spinal fluid are often associated with these disorders, though they cannot help identify the primary tumor.

How does it work?

Before the examination begins, a radioactive substance is produced in a machine called a cyclotron and attached, or tagged, to a natural body compound, most commonly glucose, but sometimes water or ammonia. Once this substance is administered to the patient, the radioactivity localizes in the appropriate areas of the body and is detected by the PET scanner.



- Different colors or degrees of brightness on a PET image represent different levels of tissue or organ function. For example, because healthy tissue uses glucose for energy, it accumulates some of the tagged glucose, which will show up on the PET images. However, cancerous tissue, which uses more glucose than normal tissue, will accumulate more of the substance and appear brighter than normal tissue on the PET images.

Tracers

1. PET can follow labeled compounds in *trace* quantities.
2. the labeled compounds can be introduced into the body without affecting the normal processes
3. Often you want to follow the time course of a compound in the body by introducing trace quantities of a compound that will behave the same as the unlabeled compound *without altering* the ongoing physiological state of chemical processes of the body.
4. PET is sensitive to detect trace amounts of labeled compound to study its behavior and the processes inside the body

How is it performed?

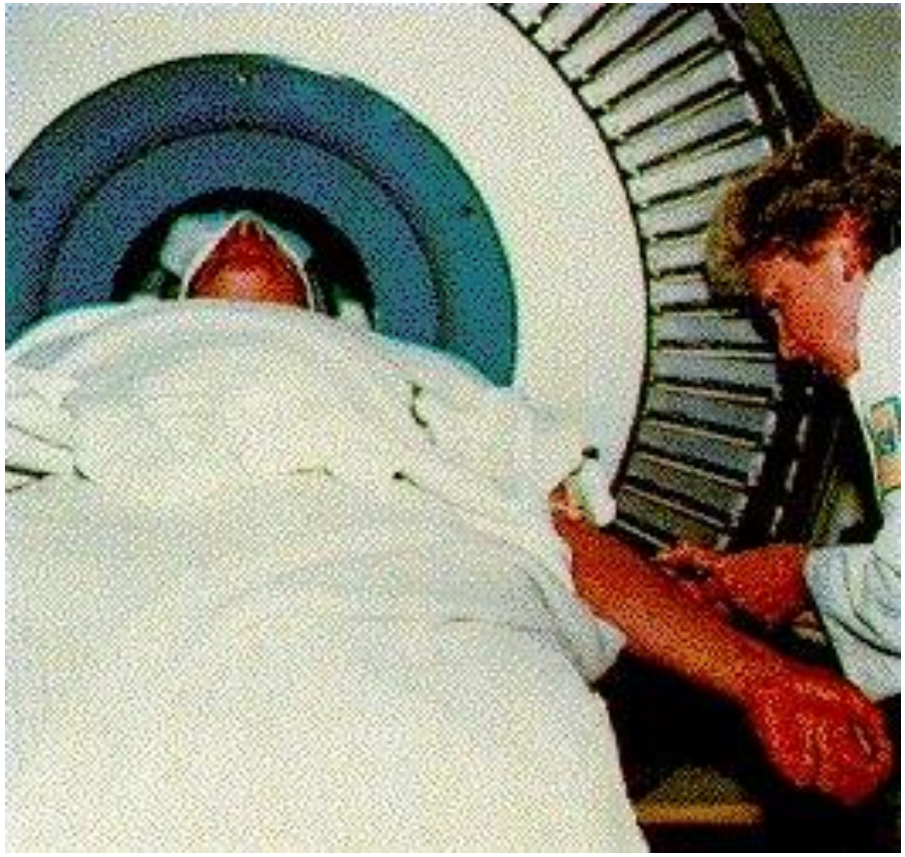
1. A nurse or technologist will take you into a special injection room, where the radioactive substance is administered as an intravenous injection (although in some cases, it is given through an existing intravenous line or inhaled as a gas).
2. It will then take approximately 30 to 90 minutes for the substance to travel through your body and accumulate in the tissue under study. During this time, you will be asked to rest quietly and avoid significant movement or talking, which may alter the localization of the administered substance. After that time, scanning begins. This may take 30 to 45 minutes.
3. Some patients, specifically those with heart disease, may undergo a stress test in which PET scans are obtained while they are at rest and again after undergoing the administration of a pharmaceutical to alter the blood flow to the heart.
4. Usually, there are no restrictions on daily routine after the test, although patient should drink plenty of fluids to flush the radioactive substance from your body.

What are the benefits vs. risks?

- Because PET allows study of body function, it can help physicians detect alterations in biochemical processes that suggest disease before changes in anatomy are apparent with other imaging tests, such as CT or MRI.
- Because the radioactivity is very short-lived, your radiation exposure is low. The substance amount is so small that it does not affect the normal processes of the body.
- PET imaging has been shown to improve detection of a variety of cancers, and earlier tests have suggested this technique may be useful in identifying small tumors in patients with paraneoplastic neurological disorders.
- The radioactive substance may expose radiation to the fetus in patients who are pregnant or the infants of women who are breast-feeding. The risk to the fetus or infant should be considered in relation to the potential information gain from the result of the PET examination. If you are pregnant, you should inform the PET imaging staff before the examination is performed.

Things to consider

- The patient will remain still for a long time.
- Claustrophobic persons may feel some anxiety.



Summary of P.E.T

- 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 (C-11, Fl-18, O-15 or N-13) that has 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. The results are evaluated by a trained expert.