

Positron Emission Tomography (PET)

- The principle of **positron emission tomography (PET)** is that radiation emitted from a radiopharmaceutical injected intravenously into a patient is registered by external detectors positioned at different orientations.
- The isotope distributes within different tissues according to the carrier molecule (isotopic labeling) and emits a positron (a positively charged electron).
- This positron in turn interacts with a free electron and an annihilation reaction occurs, resulting in the production of two 511-KeV photons emitted at almost 180° to each other.
- Then, the distribution of radioactivity is estimated by (filtered) backprojection methods.
- The directionality of the annihilation photons (two **511-keV** annihilation photons emitted in opposite directions) provides a mechanism for localizing the origin of the photons and hence, the radioactive decay process that resulted in their emission
- A PET scanner consists of several rings of detectors around the patient. The detector crystals are often made of **bismuth germanate**.
- Electronically coupled opposing detectors simultaneously identify the pair of γ photons by using coincidence detection circuits that measure annihilation events within 10-20 ns.
- There are many cyclotron-generated positron-emitting radiopharmaceuticals (e.g., ^{11}C , ^{13}N , ^{15}O , ^{18}F , and ^{68}Ga). To date, most clinical applications of PET scans have employed **^{18}F -labeled fluoro-2-deoxyglucose (^{18}F -FDG)**.
- ^{18}F FDG is a glucose analog radiopharmaceutical that **has a half-life of 110 min** and is commonly used for studying brain and heart glucose metabolism and for detecting cancer metastases.
- **Hybrid PET/CT** imaging allows fusing of the anatomic data of CT with the functional information of PET, offering improved localization of metabolic abnormalities and thus, more accurate detection of malignant lesions in the head and neck.

Differences between SPECT Scan vs. PET Scan

- Tracer utilized: PET scans utilize radioactive tracers that emanate positrons, as fluorodeoxyglucose (FDG). SPECT utilizes tracers that emanate gamma beams, similar to technetium-99m.
- Identification strategy: PET distinguishes sets of gamma beams transmitted when a positron meets an electron
- Resolution: PET images have higher resolution, around 5mm. SPECT resolution is lower at 10-20mm. PET can detect smaller abnormalities.
- Applications: PET is better for cancer detection and some brain imaging due to its resolution. SPECT is often used for bone scans and heart/blood flow imaging. Both are used for neurological disorders.
- Availability: SPECT machines are more widely available. PET requires an on-location cyclotron to deliver fleeting radioisotopes, so it might take more time to plan a PET output.
- By and large, PET scans are more costly than SPECT filters in view of the extra costs of delivering PET radioisotopes.
- Pictures: PET pictures show metabolic cycles, similar to glucose take-up. SPECT shows blood stream and take-up of tracer in tissues over the long haul.
- Safety: Both scans use very small amounts of radioactive tracers that are quickly eliminated from the body. The radiation exposure is minimal and similar between the two tests.

- Preparation: Patients may need to fast for a few hours before certain PET tracers like FDG. No special prep is normally required for SPECT.
- Procedure: It takes about 30-60 minutes to inject the tracer and acquire images. Patients lie still in the scanner during image acquisition which takes 20-40 minutes.
- Imaging area: Either scan can focus on specific body regions like the brain, heart, bones or whole body. Common areas are brain, lungs, liver, bones for cancer staging.
- Combination scans: Some machines can perform PET/CT or SPECT/CT scans, combining functional images with anatomical CT scans to better locate areas of tracer uptake.
- Uses in cancer: Beyond detection, PET is useful for staging and monitoring response to treatments. Both help guide biopsies to suspicious lesions.
- Cardiology: SPECT is best for measuring heart function and blood flow. PET provides data on metabolic processes and can detect myocarditis.
- Neurology: Both useful for epilepsy, dementia and movement disorders. PET-FDG may identify early Alzheimer's changes before structural MRI changes.

In gist, while both are nuclear medicine scans, PET provides higher resolution images useful for detecting cancer due to its unique detection method and tracers. SPECT remains valuable for applications like cardiac imaging where its availability and lower cost are advantages.

