Positron emission tomography

Gamma rays

The gamma rays emitted during radioactive decay of a given radionuclide have at most a few specific energies (forming a line spectrum) that are characteristic of the nuclide that emits them. Gamma rays have identical properties to X-rays.

positron emission imaging

It is an imaging technique in nuclear medicine that shows three-dimensional images of some organs of the body and what may be a cancerous tumor in them, as it can lose various functional processes in the body, such as the vital processes of the digestive system. The imaging device works on the basis of the discovery of pairs of gamma rays emanating indirectly from a radioactive isotope that is a source of positrons (positively charged electrons). The radioactive material is injected into the patient's body, so the radioactive substance is concentrated in the organ to be examined, such as the brain, kidneys or liver. Then the measurements of the gamma rays emitted by the organ are recorded and a three-dimensional image of it is built by the computer, which can be viewed on a screen connected to the computer.

The most common positron emitter used in PET is ^{18}F. When ^{18}F emits a positive beta particle (positron), this travels for about 2 mm through the patient before being annihilated by a negative electron. Their combined mass (positron plus electron) is converted into two energetic photons, each of exactly 511 keV, emitted simultaneously and in practically opposite directions (but not exactly so, if the positron is moving when annihilated). PET imaging (Fig. 8.15) is based on detecting these two annihilation photons in coincidence and identifying their origin in the patient to locate the radioactive source.

A positron or PET camera comprises a ring, hexagon or other polygon surrounding the patient and composed of a very large number of solid detectors (10 000–20 000)often of bismuth germanate (BGO). The ideal choice would be readily available, cheap to produce, and easy to manufacture into crystal blocks, with:

- high detection efficiency – to absorb and convert

511 keV photons into light

- very short scintillation decay time
- good energy resolution.

Positron emission tomography detectors are commonly made in block format, coupled to photomultiplier tubes (see Fig. 8.16). Note that the detector material, configuration, number of detector blocks and number of photomultiplier tubes depend on the manufacturer, but the principles of operation are the same. as in Figure 8.17, the annihilation photons from the event at (a) enter detectors A and B, they produce simultaneous (coincident) pulses, which are then accepted and combined by the electronics. Any pulses that do not coincide in time are ignored by the electronics, as are any single photons of background radiation. These two detectors therefore measure only the sum of the activity present along a line AB, called the line of response (LOR) – and similarly for each of the many pairs of detectors – which is just the information required for tomographic reconstruction, as in CT .

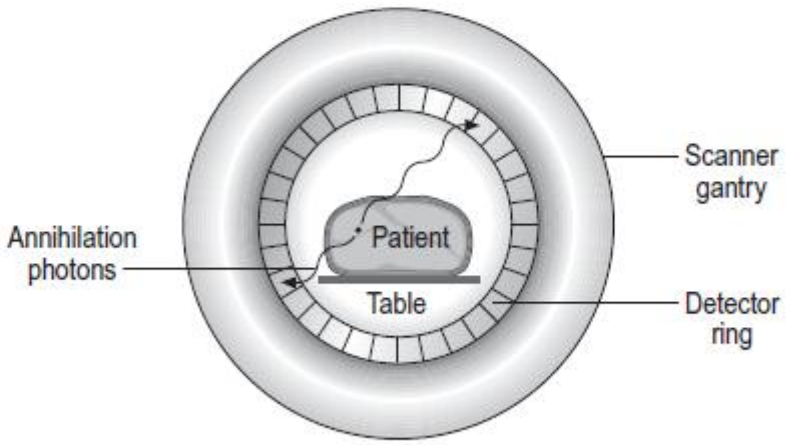

Figure 8.15 Cross-section through a patient inside a positron emission tomography scanner.

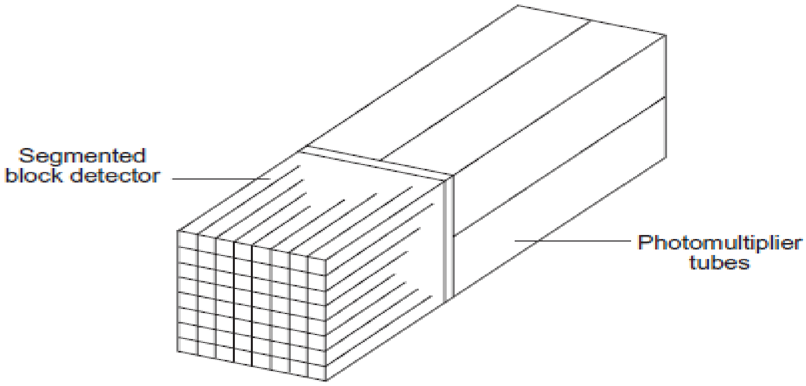

Figure 8.16 Block detector configuration commonly used in positron emission tomography scanners, with opaque reflective layers in the slots between the segments.

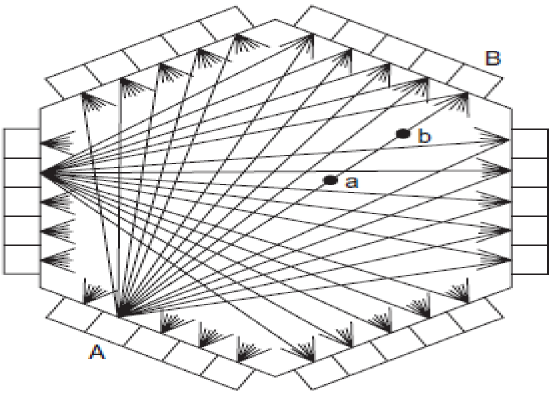

Figure 8.17 A positron emission tomography imaging system showing some lines of response. The event at a is detected at A and B in coincidence.

For the imaging procedure, the patient is injected with an array of short-lived radioisotopes such as fluorine-18, and the substance is usually injected into the circulation. The method of preparing radioactive fluorine 18 using a cyclotron, the pen is injected into the patient's body and after a short period its concentration rises in the tissues of the organ required for imaging, and the person is placed in the imaging with a positron emission device

When the radioactive isotope decays (also known as beta decay) it emits positrons (which are positively charged electrons), i.e. antiparticles of electrons due to their different charges. These positrons continue to shoot out a few millimeters and quickly collide with an electron and this results in the annihilation of an electron-positron, resulting in two photons of Gamma rays emit in opposite directions These photons are detected when they reach the scintigraphy where they emit a flash that is picked up by devices known as photo-amplifying diodes, which are electronic diodes with a large photosensitivity. Typically, the sensor is a circuit of these sensitive valves surrounding the person exposed to imaging.

- Comparatively short-lived gamma-emitting radiopharmaceuticals are used for gamma imaging.
- The activity is measured, strictly limited usually to some megabecquerels (MBq), before being administered to the patient, making them temporarily radioactive.
- Most nuclear medicine investigations deliver an effective dose of less than 5 mSv.
- Care is needed to avoid radioactive contamination.
- Once the radiopharmaceutical has time to locate in the organs of interest, the patient is scanned with a gamma camera or omographic imager for positron emitters (PET).
- The camera crystal, converts the emitted gamma photons to light; these are detected by the photomultiplier tubes and analysed to produce the image.