

Technical Aspect And Clinical Applications Of A Newer Technique

By Dr. GHIDA MOUHARRAM

*Clemenceau Medical Center affiliated with Johns Hopkins Medicine International (CMC hospital)
First PET/CT in the region at CMC*

THE COMBINATION OF A PET SCANNER AND A CT SCANNER IN A SINGLE PET/CT DEVICE:

Positron emission tomography (PET), now almost 30 years after its initial development, has become an established nuclear imaging modality that has proved especially useful in oncology.

PET was invented at the Mallinckrodt Institute of Radiology at Washington University in the mid 1970s and was soon adopted into neurology and cardiology as a valuable research tool.

However, it took more than a decade for investigators to realize that PET also could be a powerful tool for oncology. PET is a very expensive modality, requiring not only a million-dollar-plus PET scanner but also expensive equipment and highly trained personnel to generate the radiopharmaceuticals used for PET imaging. Unlike computed tomography (CT) or magnetic resonance imaging (MRI), which show anatomic detail, PET images depict **biochemical or physiologic phenomena**. Because of this, **PET offers substantial advantages over anatomic imaging modalities** in oncologic imaging. **PET can often distinguish between benign and malignant lesions when CT and MRI cannot.**

The basis of PET imaging is the labeling of small, biologically important molecules, such as sugars, amino acids, nucleic acids, receptor-binding ligands, or even water and molecular oxygen, with positron-emitting radionuclides. When these positron-emitting tracers undergo radioactive decay, their positions can be detected by the PET scanner. By imaging the temporal distribution of these labeled compounds, we can create “**physiologic maps**” of the functions or processes relevant to the labeled molecules.

Numerous different types of tracers have been developed for imaging with PET, but the vast majority of clinical



oncologic PET studies performed at present utilize an analog of glucose, **^{18}F -2-fluoro-2-deoxy-D-glucose (FDG)**. The use of FDG to image glucose metabolic rate takes advantage of the observation, first made 75 years ago, that malignant cells have higher rates of aerobic glycolysis than normal tissues (1). Thus, the malignant cell utilizes more glucose to meet its energy needs. Although malignant cells often differ from normal tissues in many other ways (e.g., levels of specific receptors, rate of nucleic acid uptake and incorporation, rate of amino acid uptake and incorporation, and a host of other biologic characteristics that could be measured with PET), **FDG is currently the only agent approved by the Food and Drug Administration (FDA) for oncology studies.** Fortunately, while FDG is not a perfect imaging agent

(some tumors show poor FDG avidity and some benign processes show high FDG avidity), FDG does work very well in most malignant tumors of clinical importance, with the largest exception being prostate cancer.

HARDWARE AND TECHNIQUES FOR PET

PET imaging is “coincidence” imaging, which is different than the other imaging techniques used in nuclear medicine. PET images are collected by surrounding the patient's body (or a part of the patient's body) with multiple rings of specialized detector crystals (Figure 2). Each decay event yields a positron, which is a positively charged electron. This positron typically travels only a few millimeters in tissue before undergoing an “annihilation reaction” with an electron, whereby both particles convert all of their mass into energy, which is predominantly released in the form of two 511-keV photons traveling in opposite directions. The PET scanner detects these photons simultaneously (or “in coincidence”), so the event is recorded and localized as a positron annihilation, or “event.” By collecting millions of these events, modern PET devices use sophisticated hardware and software to reconstruct images of the distribution of the PET tracer.

WHY PET/CT?

CT has been the cornerstone of oncologic imaging for over 20 years but lacks the ability to show crucial differences in physiology. PET has incomparable abilities to determine the metabolic activity of tissues but needs the assistance of higher-resolution, anatomic information that it cannot provide. **CT is the easiest and highest-resolution tomographic modality to integrate into PET imaging.** The combination of the two offers the best of both worlds in an integrated data set and thus improves diagnostic accuracy and localization of many lesions.

PET CT SCANNING PROCESS:

The PET/CT scanning process is as follows.

Sixty to ninety minutes after the FDG has been injected, the patient is placed supine on the imaging table. Then, just as with a diagnostic CT, the CT tube and detector are used to obtain a topogram, which is essentially a digital x-ray of the entire field of interest.



The topogram is used to map out the precise portion of the body to be scanned, and those coordinates are entered into the system. The scanner software then automatically realigns the table, and a spiral CT is performed of the area of interest (usually the base of the skull through the

mid-thigh for most oncology studies), generating literally hundreds of transaxial images through the body.

ADVANTAGES OF PET/CT

Aside from the overall decreased scan time, major clinical advantages of PET/CT include:

- **better localization of activity to normal vs abnormal structures,**
- better identification of inflammatory lesions, CT visualization of PET-negative lesions (especially bone lesions),
- discovery of serendipitous abnormalities,
- confirmation of unusual or abnormal sites,
- improved localization for biopsy or radiotherapy.

CONCLUSION

In oncology, the combination of separate CT and FDG-PET has become, in the past decade, the standard of imaging care for many oncology patients. The recent integration of these two modalities into a single scanning device offers several major interpretive and clinical advantages.

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