



PET FACT SHEET

In the dramatically changing world of diagnostic imaging the current revolution taking place in Nuclear Medicine is among the most exciting. The development of whole-body Positron Emission Tomography (PET), together with the imaging agent ^{18}F fluorodeoxyglucose (FDG) enables the accurate non-invasive detection and staging of cancer. Pioneered by scientists at UCLA and developed by CTI PET Systems, Inc., this technology has resulted in a convincing body of knowledge that can now be applied to benefit patients with cancer.

With the increasing availability of commercially manufactured FDG, there is a growing body of evidence that whole-body PET imaging is advantageous for patient care quality and cost-effective patient management. PET offers a comprehensive assessment for both the initial staging of newly diagnosed cancers, ranging from lymphoma to lung tumors, as well as in treatment. The extent and stage of disease can be determined accurately to enable a rational decision for patient management.

PET was developed in the late 1960's, but recent developments have resulted in its recognition as an invaluable clinical test for tumor imaging. No other imaging modality has comparable potential because PET has the unique ability to image functional processes, such as tumor metabolic activity, in vivo. The basic principals of PET are based on the detection of photons emitted from the patient after the intravenous injection of a short-lived radiopharmaceutical (^{18}F or FDG, a sugar analogue). These photons are detected by the PET scanner and allow the reconstruction of a three dimensional image of the glucose metabolism in the body. The ability to image glucose metabolism non-invasively is important, because most malignant tumors exhibit a high glucose metabolic activity (1,2). The most recent feature of PET is the capability to acquire tomographic whole-body images. Whole-body PET images can be displayed in transaxial, coronal, or sagittal image planes. The images from the first prototype, developed by Drs. Michael Phelps and Edward Hoffman at UCLA, took one and a half days to reconstruct. Today, the same reconstruction takes only a few minutes. The results are 3-dimensional images of the body which can be used to localize normal and abnormal processes, providing clinicians with information about the tissue biochemistry that is unobtainable by other imaging modalities. Anatomical imaging procedures such as CT or MRI frequently cannot distinguish between malignant disease and invasive tissue biopsies are frequently the only means to assess the nature of a tumor.

The patient should fast after midnight on the day prior to the study. The patient receives an intravenous injection of the radiopharmaceutical FDG. The actual scan begins approximately 45 minutes to one hour later to allow sufficient time for the tracer to accumulate in abnormal tissue. While lying on a comfortable table, the patient is moved slowly through the scanner to obtain images of the entire body. There are no side effects to this procedure and the amount of radiation injected is well within the safe levels. The scans take about 60 to 90 minutes.

The PET images are created with the help of three technologies:

- the cyclotron, which produces safe radioisotopes.
- the scanner, which records the location of the radio tracer as it accumulates in different tissues in the body and
- a computer, which reconstructs the signals into 3-dimensional images of the body.

A large body of literature indicated that FDG-PET scanning is useful to differentiate malignant from benign tumors, as well as to determine the extent and stage of cancer. This is of paramount importance to guide physicians to the best therapeutic approach i.e., chemotherapy vs. radiation therapy vs. surgery. In up to 15% of patients, PET will detect otherwise unsuspected metastatic disease, which alters the treatment strategy. PET is also unique in its capability to differentiate between residual scar tissue, radiation necrosis and tumor recurrence and, in some cases may be useful in assessing the patients progress in a given therapeutic regimen. Research shows PET to be useful to detect or stage these types of cancer:

Solitary Pulmonary Nodule

The nature of a solitary pulmonary nodule can be determined with high accuracy using FDG-PET imaging. For nodules greater than 1 centimeter in diameter the overall sensitivity and specificity are 83 and 90%, respectively. In contrast, the nature of such solitary nodules cannot be determined with anatomical imaging modalities such as CT or MRI. Moreover, PET imaging is a non-invasive method and thus not associated with any morbidity as compared to lung biopsy. (3,4)

Lung Cancer

The overall sensitivity and specificity of FDG-PET for detecting lung cancer is on the order of 90%. In addition to the detection of disease, the metastatic spread of the disease can be determined, which has important implications for patient management. This is particularly important in non-small cell lung cancer, where a cure can be achieved only by complete surgical resection of the tumor. Tumor involvement of the mediastinum at the time of initial diagnosis carries a poor prognosis (five-year survival rates of only 5-10%). In contrast, if the mediastinum is free of disease, the 5-year survival approached 40%.

Knowledge of the stage of the disease is therefore critical before a patient is exposed to the potentially unnecessary risk of thoracotomy. Recent prospective studies confirm that PET is significantly more accurate than CT for staging mediastinal involvement. The accuracy was reported to be 85% for PET but only 52% for CT. There are several reasons for the superiority of PET:

- High FDG uptake signifies malignancy event in normally sized lymph nodes (i.e., <1cm in diameter),
- Enlarged lymph nodes might be benign as demonstrated by absent FDG uptake. In general, the sensitivity of and specificity of PET for detecting metastatic lymph nodes are 83 and 84% as compared to 63 and 73% for CT. These data support the notion that PET is the imaging method of choice for staging of the disease in-patients with non-small cell lung cancer.

Additional data supports the use of FDG-PET to detect extrathoracic metastases in lung cancer patients. These studies demonstrated that PET detected extrathoracic metastases in up to 30% of the patients with lung cancer. Before the PET study, these patients were thought to be curable by surgery. More importantly, in 41% of these patients the management strategy was altered by PET. The reported sensitivity for detecting extrathoracic metastatic disease has been shown to be 87%. Finally, assessing the response to treatment in lung cancer patients has tremendous economic benefits. A single PET scan can replace the usual follow-up (several CT scans of the chest, abdomen and pelvis, bone scans, and MRI). (5,6,7,8,9,10)

Head and Neck Cancers

Studies using PET have shown an excellent diagnostic accuracy for detection and staging of head and neck cancers. Overall, a sensitivity of 88% for detecting primary lesions and 81% for uncovering metastatic disease has been reported. These values compare favorably with those obtained by CT or MRI (78 and 71%). (11,12)

Colorectal Cancer

PET has been shown to be superior to CT for evaluating patients with recurrent colorectal cancer. Prospective studies have demonstrated that the accuracy of PET is 87% vs. 65% for CT. PET detects primary tumors, metastatic lesions, and liver metastases as well as recurrent disease. (13,14,15)

Melanoma

The incidence of melanoma is increasing rapidly. PET plays important role in staging of the disease. Intra-abdominal metastases were detected in 100% of cases in two recent studies. Thus, PET is useful for designing the best treatment for patients with melanoma. (16,17)

Lymphoma

PET has been demonstrated to have excellent accuracy for imaging thoracic and abdominal lymphoma, irrespective of cell type or grade. In this regard, PET has been shown to detect more lesions than CT. Whole-body PET has an advantage over conventional staging (with multiple CT examinations) in being more sensitive in disease detection, and therefore staging, as well as reducing overall cost of such evaluations. In addition, it has advantages over CT for the follow-up of patients as it has the ability to differentiate between active disease and post-treatment fibrosis, particularly following radiation treatment. (18)

Breast Cancer

The use of FDG PET for imaging primary regional and systemic metastases has been demonstrated in this group of patients. The sensitivity of whole-body PET for staging recurrent metastatic breast carcinoma is 93% with a specificity of 79%. It is particularly useful for the detection of primary lesions in young women with dense breast tissue. (19)

Compiled Data	
Detection & Staging of Cancer by PET²¹	
Cancer Type	Diagnostic Accuracy
Solitary Pulmonary Nodule	94%
Lung Cancer	91%
Head and Neck Cancer	92%
Colorectal Cancer	94%
Melanoma	88%
Lymphoma	97%
Breast Cancer	92%
Ovarian Cancer	81%
Muscular-skeletal	93%
Pancreatic	92%
Metastatic Thyroid	100%

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