

PET/CT

TWO VIEWS - ONE VISION



Medical Arts Radiology

PET/CT IMAGING: TWO VIEWS - ONE VISION

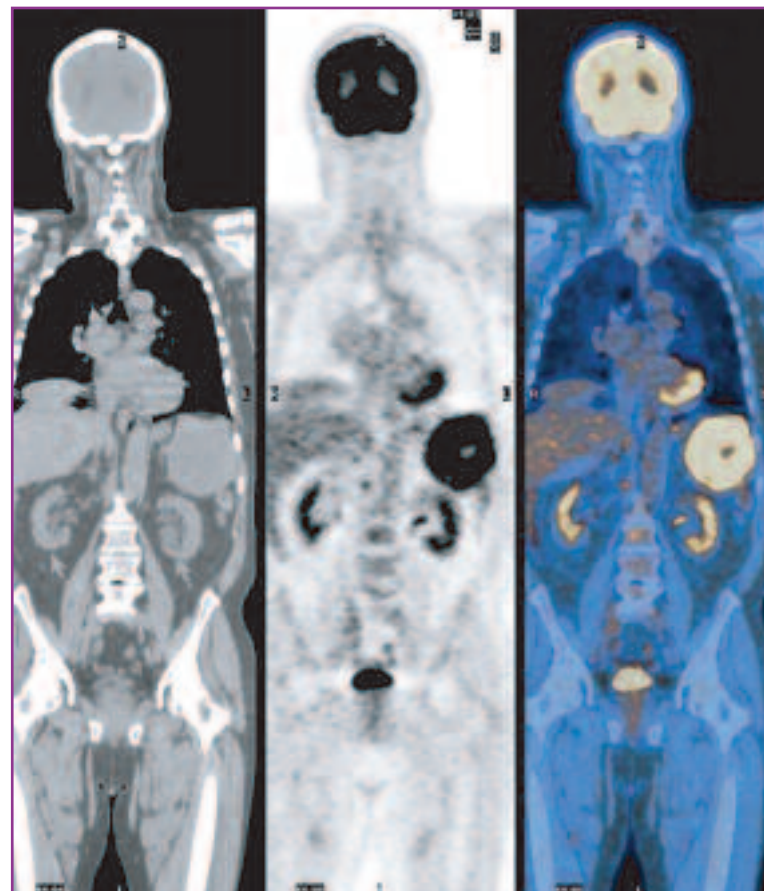
Committed to providing the latest advances in diagnostic imaging, Medical Arts Radiology is proud to introduce fully integrated PET/CT. This hybrid technology combines the strengths of two well-established imaging modalities into a single device, making it possible to collect both anatomical and biological information during one examination. *The power of integrated anatomic and functional imaging makes a difference in clinical practice and combined PET/CT is revolutionizing the field of oncology.* Clinical studies have shown that in comparison to PET and CT scans alone, integrated PET/CT offers tremendous benefit to patients – earlier diagnosis, greater accuracy in staging and localization, and more precise treatment and patient monitoring. *As the first site in Suffolk County to offer PET/CT, Medical Arts radiologists have extensive experience in the performance and interpretation of this revolutionary new technique.*

How PET Works

Positron Emission Tomography (PET) is performed with the agent fluorodeoxyglucose (FDG), which is selectively metabolized and trapped by an enzymatic reaction with hexokinase in cancer cells. Since this reaction determines the rate and magnitude of FDG accumulation, **FDG-PET imaging can be used to quantify glucose utilization and thus reveals subtle metabolic processes, such as tumor growth.** When this information is merged with the anatomical details of CT, the scanner creates a precise image enabling radiologists to accurately detect and localize many cancers, including breast, esophageal, melanoma, lymphoma, lung, colorectal, and head and neck.

Combined PET/CT Imaging: Advantages over PET alone or Software Fusion of PET and CT

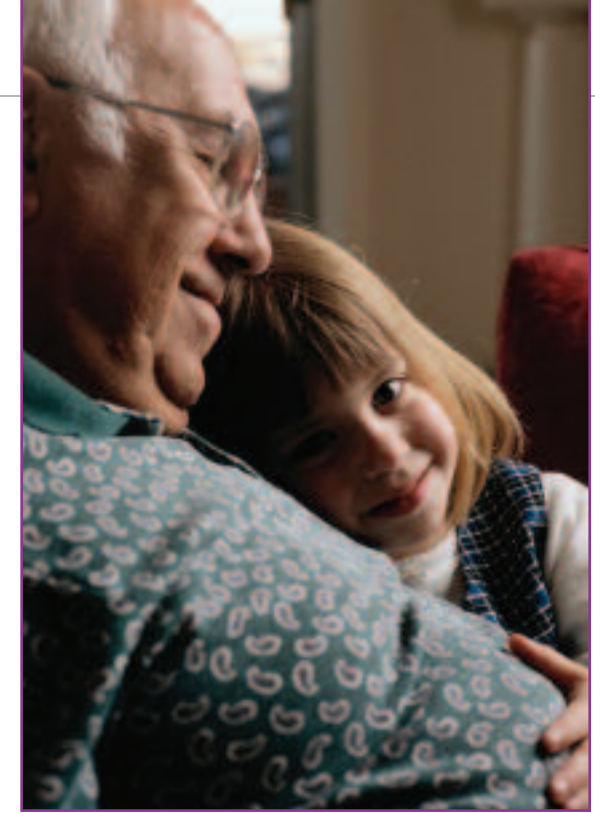
Integrated PET/CT is superior to fusion software commonly applied as a low cost means of correlating PET and CT images. If PET and CT are performed separately, even a slight change in body position between the two scans can often lead to misinterpretation of the exam. Because patient positioning is more consistent between anatomical and functional images on an integrated system, the PET/CT scanner enables easier, more accurate and more effective image correlation. *Clinical research has shown that in comparison to a PET scan alone, PET/CT technology provides new information that can alter a patient's treatment plan to better target the cancer in approximately one-third of cases.*



Multimodality PET/CT images from a single scan session

A Whole New World For Patients

- **Improved diagnostic confidence** for patients suspected to have cancer, and those who already have a known malignancy.
- Potential **reduction of invasive procedures** such as biopsies and unnecessary surgeries.
- **Greater peace of mind** for patients and their families, knowing that this technology provides comprehensive information. PET/CT also eliminates a “wait and see” approach, used commonly to monitor patients during and after therapy.
- **Increased patient comfort** due to *shorter exam time.*



A Whole New World for the Medical Community

- Excellent sensitivity and specificity, **resulting in clinical confidence** and the reduction of false positives and false negatives.
- **Better distinction between physiological uptake and pathological uptake.**
- **Superior lesion localization from near-perfect anatomical/functional registration.** Integrated PET/CT more accurately localizes metabolic activity to the appropriate anatomic structure or location, crucial for studies of small structures such as a lymph node, a bowel loop, or a vocal cord.
- PET/CT can **help in selecting specific areas within a larger lesion for biopsy or surgical intervention.** In larger lesions, PET/CT can help define the location of necrotic tissue and differentiate tumor versus scar tissue.
- Radiation oncologists need **maximum information for radiation therapy planning**, and PET/CT data files can be imported into many radiation therapy planning computers. For example, IMRT can deliver precise amounts of radiation to complex 3-D volumes, fully utilizing PET/CT datasets.
- PET/CT has a **shorter scan time** (avg. 30 minutes to complete, vs. 60 minutes with standard PET). This aids in patient comfort, as well as **fewer motion artifacts** and fewer problems with claustrophobia.

Patients With These Diagnoses May Benefit From PET/CT Scans:

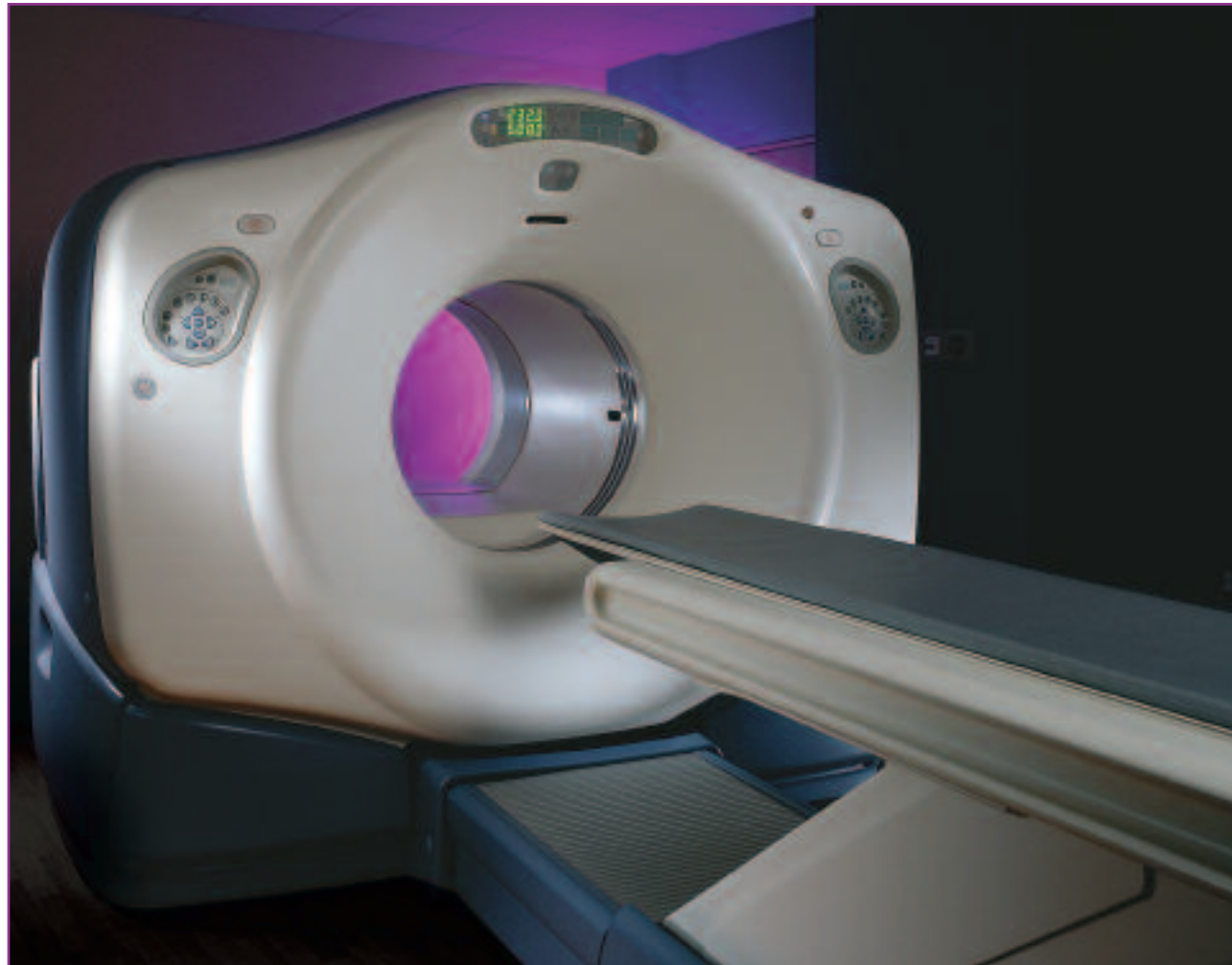
- Breast Cancer
- Head and Neck Cancer
- Solitary Pulmonary Nodule
- Colorectal Cancer
- Esophageal Cancer
- Lymphoma
- Melanoma
- Lung Cancer

PET/CT PROCEDURE

In PET/CT, both the multidetector CT instrumentation and the PET detectors are mounted in the same gantry, one immediately behind the other. Both PET and CT are performed while the patient lies in the same position on the imaging table.

Patients receive an injection of ^{18}F -FDG-PET about an hour before the start of imaging to allow time for metabolic uptake of the tracer. At the start of the examination, the patient is positioned comfortably on the imaging table and is asked to stay motionless for the duration of the imaging procedure. A low dose non-contrast transmission CT scan is performed first, which provides data to correct for attenuation for the PET scan. The FDG-PET scan is performed next, which takes about 20-25 minutes, depending on the size of the patient, for a routine whole-body scan, which entails neck, chest, abdomen, and pelvis. After the PET scan is complete, intravenous contrast is administered to the patient before a second rapid CT scan, which is used for clinical interpretation.

The radiation exposure for a PET/CT scan is about 800-1,000 mrem for each CT scan and about 1,600 mrem for ^{18}F (15 mCi). ^{18}F has a half-life of 109 minutes and is effectively fully decayed within a few hours of administration.

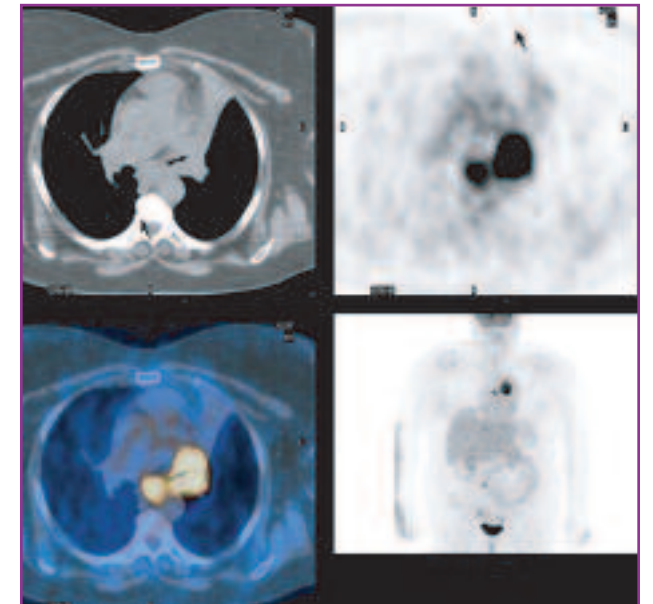


PET/CT AT MEDICAL ARTS RADIOLOGY... A powerful tool for you and your patients

LUNG CANCER

One of the first influential studies showing the value of integrated PET/CT (“hybrid imaging”) was conducted at the University of Zurich, Switzerland, and published in the New England Journal of Medicine in 2003. The study found that *integrated PET/CT was significantly better at staging lung cancer than PET alone, CT alone, or PET and CT using visual correlation*. In approximately 40% of patients, integrated PET/CT offered additional important diagnostic information, including exact location of lymph nodes, precise evaluation of chest wall infiltration, mediastinal invasion, differentiation between tumor and peritumoral inflammation or atelectasis, and the exact location of distant metastases.

The high sensitivity of PET for malignancy means that non-FDG-avid lesions are highly unlikely to be malignant. There are occasional false-negative PET scans, primarily occurring with well-differentiated adenocarcinoma and bronchoalveolar cell carcinoma. For this reason, most patients with a negative PET scan are still followed up radiographically to firmly establish a benign diagnosis. PET-negative lesions followed up in this way are usually truly benign, and those that do prove to be malignant are usually stage I nonmetastatic tumors, which have an excellent prognosis after resection.



Non-small cell lung carcinoma. Axial CT, FDG-PET, and fused PET/CT images demonstrate left hilar neoplasm encasing upper lobe bronchus with associated metastatic subcarinal lymph node. PET/CT clearly distinguishes the tumor from adjacent atelectatic lung.

Indications for PET imaging in non-small cell lung carcinoma:

- **Diagnosis:** Scans done prior to tissue confirmation of malignancy
- **Staging:** After tissue diagnosis of malignancy and before initial treatment
- **Restaging:** Only after a treatment course is finished
- **Solitary pulmonary nodule:** Characterize lung nodule as benign or malignant

HEAD AND NECK CANCER

Integrated PET/CT used in head and neck imaging leads to increased confidence in image interpretation. A recent study from Memorial Sloan-Kettering evaluated the clinical usefulness of hybrid PET/CT technology in patients with head and neck cancer by comparing PET with PET/CT fusion images. Combined PET/CT more precisely defined a lesion’s anatomical location in 42% of all lesions seen by PET alone. Additionally, diagnostic accuracy was improved in 56% of equivocal PET findings, the additional information from PET/CT fusion images enabling reclassification as either benign or malignant.

Today, combined PET/CT is the method of choice when PET is performed for staging and follow-up of patients with cancers in the head and neck. While it is possible with software programs to attempt fusion of CT and PET images that were obtained at different times, the patient’s position is usually not the same in both studies, and changes in tumor size may have occurred in the interval.

Indications for PET imaging in head and neck cancer:

- **Diagnosis:** Locating site of primary disease
- **Staging:** Evaluating regional lymph nodes
- **Monitoring response to therapy**
- **Detecting recurrence and restaging**

LYMPHOMA

Although PET/CT can be used to evaluate suspicious abnormalities such as lymphadenopathy, this application is rarely used because patients often proceed to percutaneous biopsy or lymphadenectomy for diagnosis. If PET is undertaken for the diagnosis of lymphoma, it must be performed with a proper understanding of the potential causes of false-positive and false-negative results. False-negative scans can be obtained in cases of low-grade lymphoma which are not highly metabolically active. In particular, lymphomas arising from mucosal-associated lymphoid tissue (ie, MALT lymphomas) are an established cause of false-negative PET scans, and images in patients with these tumors must be interpreted with caution. False-positive PET scans also pose a frequent hazard in interpretation. Examples of diseases that have been found to be hypermetabolic include sarcoidosis, tuberculosis, histoplasmosis and other fungal infections, pyogenic abscess, and spondylodiscitis. PET is likely to be more sensitive than specific for the diagnosis of lymphoma, owing to the greater number of causes of false-positive scans than of false-negative scans.

On the other hand, PET/CT is the best imaging modality for the staging of patients with both Hodgkin and non-Hodgkin lymphoma. By assessing metabolic activity within a node, PET is not directly reliant on nodal size to determine the presence or absence of malignancy. For this reason, PET has been shown to be more sensitive and specific than CT for identification of sites of disease. Although Gallium scintigraphy has many of the advantages of FDG-PET, PET has been shown to be superior for evaluation of patients with lymphoma, with greater imaging resolution and accuracy.

In addition to nodal sites of disease, PET/CT can be useful for evaluation of extranodal disease, including liver, spleen and mesenteric/peritoneal disease. Detection of marrow disease can also be accomplished with FDG-PET. Although most

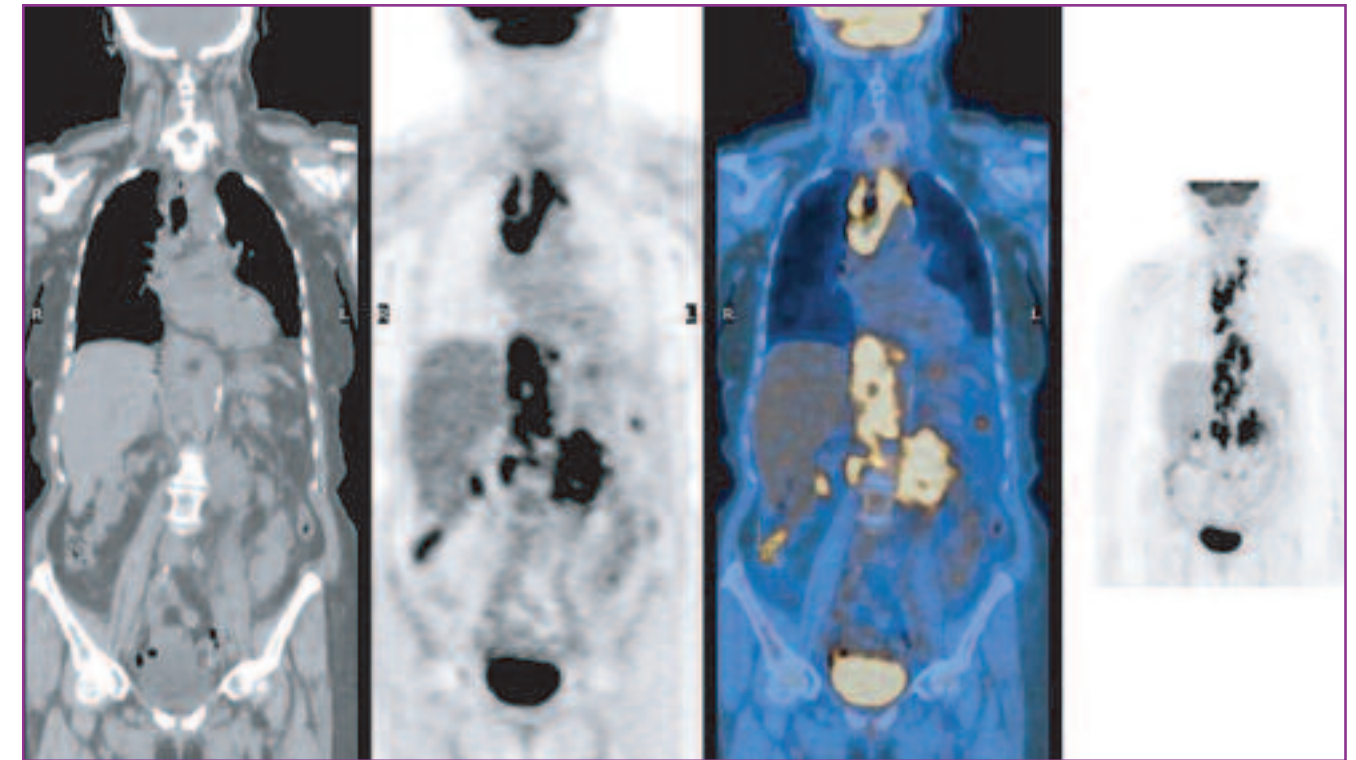
patients with lymphoma undergo bone marrow aspiration, lymphomatous involvement of the marrow is occasionally focal and may be missed at random biopsy sampling. Several studies have found that focal sites of marrow disease can be identified by PET/CT in 13%-16% of patients with negative bone marrow biopsy results. For detection of marrow disease, PET is more accurate than either gallium or skeletal scintigraphy.

Lymphomatous masses frequently respond dramatically to therapy, with marked reduction in size after effective treatment. In many patients, however, there is a residual mass after therapy, and the differentiation between residual viable lymphoma and post-treatment necrosis and fibrosis is a challenge with CT or other anatomic imaging modalities. PET/CT provides an excellent means of evaluating the physiology of these residual masses, to help determine whether additional therapy is needed. Changes in FDG uptake have been reported within 1-3 days after the initiation of therapy, and SUV values at 42 days after treatment have been found to accurately reflect the patient's overall disease status. In patients with a complete response to therapy, substantial decreases in SUVs are observed early in the course of therapy.

Once therapy is completed, PET/CT offers prognostic information based on the presence or absence of residual FDG-avid disease. In a meta-analysis of the literature, a PET/CT scan showing metabolically active tumor after treatment was found to be a strong predictor of relapse, with up to 100% of patients with persistent disease after therapy having recurrent disease within 2 years. The absence of evidence of disease on post-therapy PET/CT scans also imparts prognostic information, with a very low relapse rate in patients with a negative scan.

Indications for PET imaging in Hodgkin and Non-Hodgkin Lymphoma:

- Diagnosis
- Restaging
- Staging



Staging of non-Hodgkin lymphoma. Integrated PET/CT defines the extent of disease above and below the diaphragm on coronal CT, PET, and fused PET/CT images.

COLORECTAL CARCINOMA

PET/CT is useful for the pre-operative staging and restaging of colorectal cancer. The reported increased sensitivity of PET over CT has been attributed to the ability of FDG-PET to detect metabolic abnormalities that precede the morphologic changes seen by CT. The global nature of the PET study also contributes to increased sensitivity through the detection of distant metastatic lesions.

Several recent studies have demonstrated that combined PET/CT is more accurate than PET alone for the diagnosis and staging of recurrent colorectal carcinoma. A hybrid PET/CT study significantly improves the localization of abnormal FDG activity, reduces both overstaging and understaging of suspected or recurrent colorectal cancers, and offers lower inter-observer variability as compared to PET alone or software fusion of separate PET and CT exams.

The high sensitivity of PET/CT for liver involvement takes on added importance due to the high incidence of isolated colorectal metastases to this organ and the potential for curative resection. In this situation PET/CT can be used to establish the extent of disease in order to maximize the potential for a curative resection or to spare the patient unnecessary surgery should disease be too extensive. PET/CT is also useful to distinguish postoperative scar versus residual or recurrent disease.

Indications for PET imaging in colorectal carcinoma:

- A rising CEA level in the absence of a known source
- Equivocal lesion on conventional imaging
- Evaluation for recurrent tumor for indicators other than rising CEA, such as an abnormal CT scan finding
- Detection of hepatic and extrahepatic metastases in primary staging
- Preoperative staging prior to resection of recurrent disease
- Distinguishing local recurrence from postoperative scar

BREAST CANCER

PET imaging is a clear advance in the approach to staging and monitoring breast cancer. *Although PET/CT is very useful in identifying recurrent or metastatic breast disease, Medicare coverage for the diagnosis of primary breast tumors is currently not approved.* Tumor size and cell type are factors that effect PET scan accuracy. Although accuracy in detecting tumors larger than 2cm is high, PET may miss approximately one third of invasive cancers smaller than 1cm. PET is more likely to identify invasive ductal carcinoma, to miss invasive lobular carcinomas, and is not helpful for identification of non-invasive tumors. Currently, a few research centers are evaluating dedicated positron emission mammography devices that may potentially improve identification of small breast cancers.

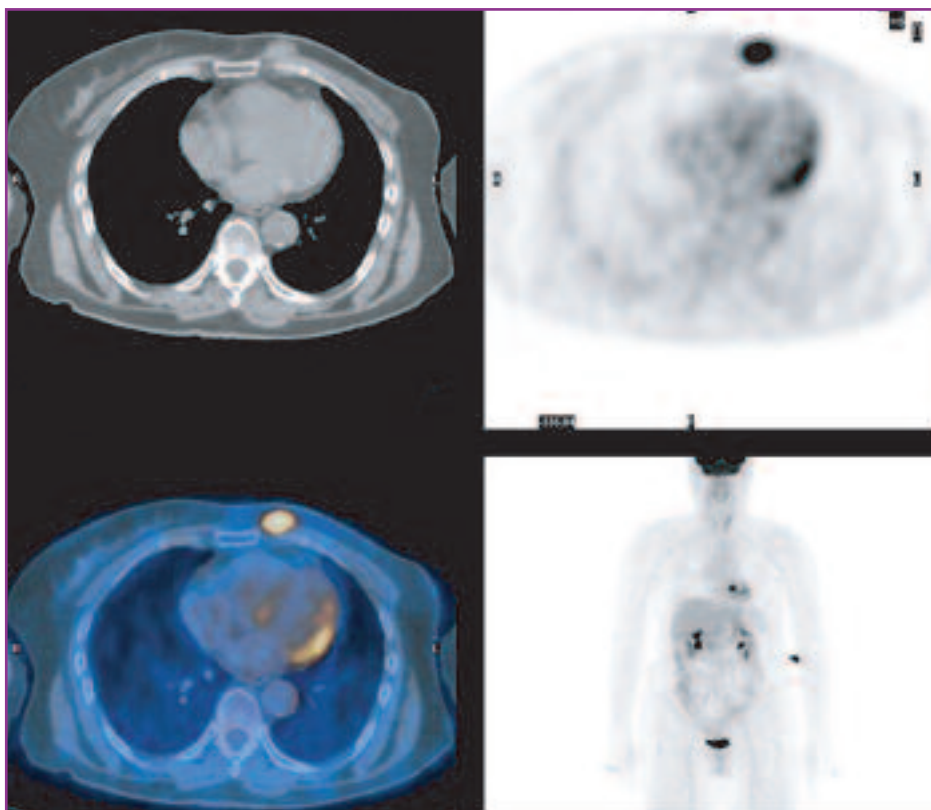
Accuracy in staging and early identification of recurrent breast carcinoma is critical for therapeutic planning, and PET/CT is an excellent method for follow-up imaging of breast cancer patients. PET is more accurate than bone scan in patients who have predominantly osteolytic bone metastases. When bone lesions are osteoblastic, they may be better seen on conventional bone scan. *In studies evaluating asymptomatic patients with rising serum tumor*

markers, PET/CT has an accuracy of 90% in detecting sites of metastatic disease. Furthermore, in patients with negative serum tumor markers but suspicious clinical findings, PET scanning appears to be more reliable than conventional imaging for identifying relapsed tumor.

Uptake of FDG in metastases can be evaluated after chemotherapy or radiation for assessment of therapy response. Some researchers have shown that it is possible to identify patients who will respond to chemotherapy if PET scanning is performed immediately after a first cycle of chemotherapy. Responders will show a rapid decline in FDG uptake in metastases, whereas, non-responders will show little or no change in FDG uptake. *PET/CT scanners are also being used to direct radiation therapy in patients who have localized metastatic disease in areas such as the chest wall or in bone.*

Indications for PET imaging in breast cancer:

- Breast cancer staging
- Restaging for locoregional or distant metastases
- Breast cancer response to treatment during therapy

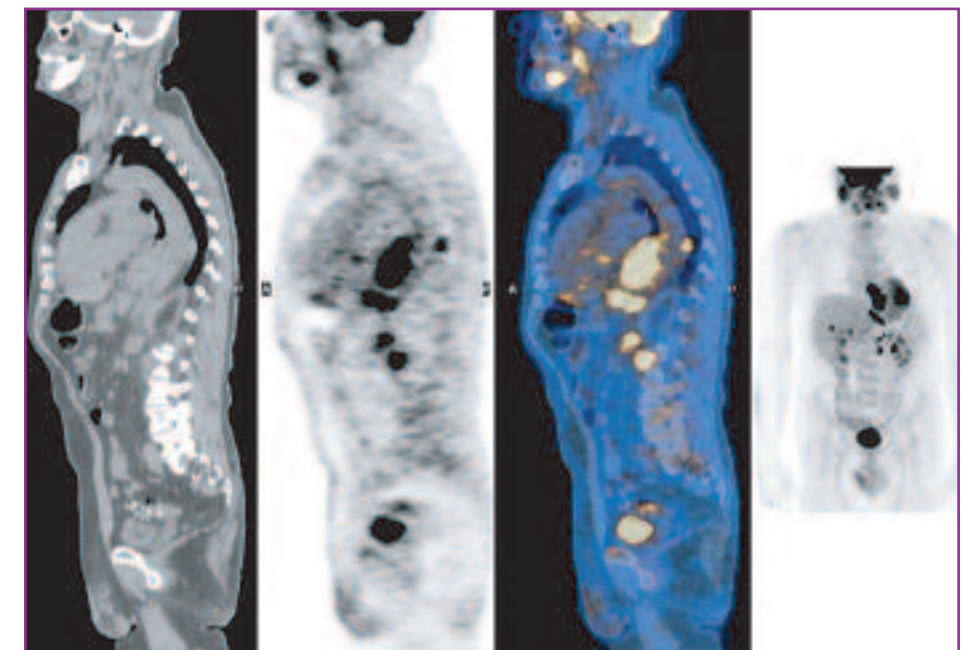


Recurrent breast carcinoma. Axial CT depicts a small non-specific soft tissue mass along the left medial chest wall in a patient who underwent mastectomy one year previously. This lesion shows intense hypermetabolism on FDG-PET and fused PET/CT images consistent with locally recurrent breast carcinoma.

ESOPHAGEAL CANCER

PET/CT is quickly becoming the gold standard for the evaluation of esophageal carcinoma. *In patients being considered for surgical resection, PET/CT provides the best staging information and can result in appropriate treatment planning in more than 90% of patients.* For initial staging, the detection of distant metastatic nodal disease on FDG-PET is substantially better than for regional nodal disease. In one study, PET was found to be 86% accurate in the evaluation of M1a nodal metastases and was more accurate than combined assessment with CT and endoscopic ultrasound. PET/CT has also been shown to demonstrate other sites of metastatic disease, and the sensitivity and specificity of PET/CT for M1b disease is higher than CT. In presurgical evaluation, the additional sites of disease detected with PET/CT compared with those detected by CT alone can have an effect on surgical management. In one study, presurgical staging with CT was 65% accurate for the presence of resectable versus unresectable disease, whereas FDG-PET was 88% accurate.

After initial treatment of esophageal cancer, patients remain at risk for disease recurrence, and despite attempted curative surgery the overall 5-year survival rate of patients with esophageal cancer is only 30%-50%. Esophageal cancer can recur locally at the anastomotic site; regionally in the periesophageal soft tissues or mediastinum; or distally in liver, lung, bone, or other sites. A recent study of patients suspected of having recurrent disease demonstrated that all local recurrences were hypermetabolic on FDG-PET (100% sensitive for local disease recurrence). However, the specificity of PET for esophageal malignancy is limited because of FDG uptake in benign esophageal conditions, and in this group of patients the specificity of PET for recurrence was 57%. False-positive PET scans were seen in patients with inflammation of the esophagus and in patients with recent balloon dilation of anastomotic strictures. Regional disease recurrence and sites of nodal and extranodal metastatic disease may also be assessed with PET/CT. *Overall, the addition of PET/CT to the conventional staging work-up in patients suspected of having disease recurrence provided additional information regarding disease stage in 27% of patients.*



Esophageal carcinoma. Staging PET/CT examination with sagittal images clearly demonstrate the extent of disease, including the primary distal esophageal lesion and metastatic lymph nodes in the mediastinum, celiac axis and upper retroperitoneum.

Indications for PET imaging in esophageal cancer (including both squamous cell carcinoma and adenocarcinoma):

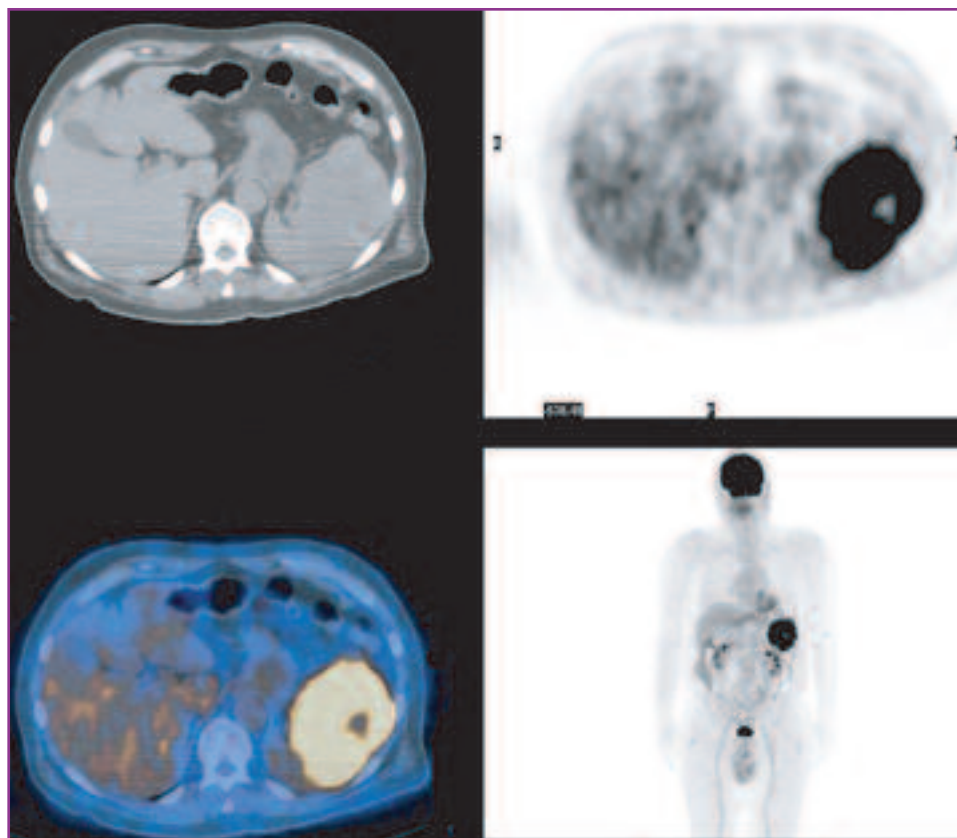
- Diagnosis
- Restaging
- Staging

MELANOMA

FDG PET imaging is of limited use in patients with early stage melanoma (I-II). These patients presently undergo surgical resection of the lesion followed by examination of the sentinel node. Sentinel node biopsy is more sensitive than PET imaging for the detection of microscopic nodal metastases. However, **PET/CT can be very useful in detecting lymph node and distant metastases - particularly in high-risk patients** (melanoma thickness greater than 1.5mm or Clark's level IV). FDG-PET imaging has been shown to be superior to conventional imaging for the detection of melanoma metastases; peripheral skin metastases as small as 3mm can be detected. Pooled data for FDG-PET imaging in the detection of melanoma metastases indicates a sensitivity of 79% and a specificity of 86%.

The detection of nodal metastases is dependent upon the size of the metastasis. Detection can be as high as 100% for metastases greater than 1cm in size, a diameter of at least 6mm is associated with a detection sensitivity of over 83%, while detection of metastases smaller than 5mm is only 23%. PET/CT is more accurate for systemic staging than for staging of regional lymph nodes - especially for patients with stage I or II disease. In fact, PET/CT should not replace sentinel node biopsy in the clinical management scheme of melanoma patients.

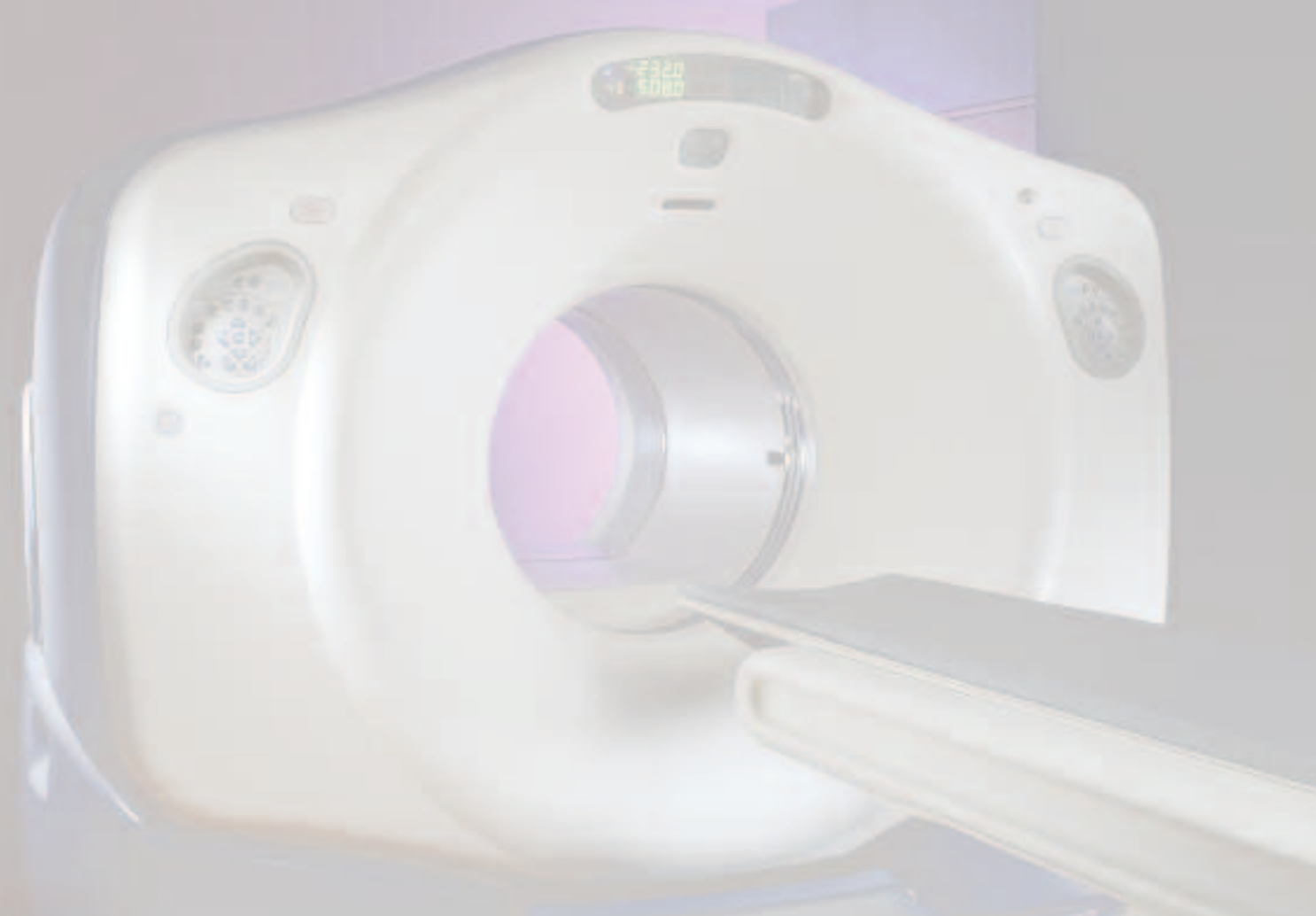
PET scan results can have a significant impact on patient management. **When PET is added to CT for the initial staging of high-risk melanoma patients, management can be changed in up to 90% of cases due to the detection of unsuspected sites of disease.**



Metastatic melanoma to the spleen. 50 year old man with a past history of melanoma presents with left upper quadrant pain and splenomegaly. Axial CT, FDG-PET, and fused PET/CT images show marked hypermetabolism throughout the spleen, proven to represent metastatic disease at splenectomy.

Indications for PET imaging in melanoma (excludes evaluation of regional nodes):

- Primary staging of high-risk melanoma (Clark Level III or higher)
- Restaging in patients with suspected or proven recurrence



EMERGING APPLICATIONS IN PET/CT

The vast majority of clinical studies performed with PET/CT make use of a single radiopharmaceutical – ¹⁸F FDG. Despite its success and widespread applicability, FDG imaging represents only a fraction of the potential of PET imaging. As other radiopharmaceuticals are developed, it is expected that PET/CT will gain acceptance in the evaluation of tumor types beyond the seven currently approved for Medicare reimbursement.

The true value of PET/CT extends beyond the mere diagnosis of disease. In the future, PET/CT will serve not only as a tool in the initial diagnosis of cancer, but also as an important tool for therapy planning and treatment monitoring of cancer patients. Beyond oncology, investigators continue to explore the imaging capabilities and potential of hybrid PET/CT. In the brain, PET/CT can identify Alzheimer's disease in its very early stages, and has also proven valuable in the assessment of seizure disorders. There is enormous potential in the application of PET/CT to cardiac imaging. Today, multidetector CT is paving the way toward noninvasive 3D CT angiography of the coronary arteries. In the future, PET/CT may enable the evaluation of cardiac motion, coronary calcification, coronary angiography, myocardial perfusion and viability – **all with a single machine!**

SCHEDULING A PET/CT SCAN

To schedule a patient for a PET/CT, please contact Medical Arts Radiology Commack:
Phone 631-462-0525 or Fax 631-462-0529.

Physicians who wish to learn more about PET/CT are encouraged to contact our Commack site to speak with a Medical Arts radiologist.

All cases presented in this brochure were performed at Medical Arts Radiology, Commack, on a GE Discovery ST PET/CT scanner.



Medical Arts Radiology

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