PET-CT Imaging in Breast Cancer

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Breast cancer is second only to skin cancer as the most commonly diagnosed cancer among women. It is also the second leading cause of cancer related death in women, after lung cancer. Approximately 212,920 women will be diagnosed with invasive breast cancer in the United States during 2006 according to the American Cancer Society. The chance of developing invasive breast cancer at some time in a woman's lifetime is about 1 in 8 (13% of women). Approximately 40,970 women and 460 men are expected to die of breast cancer in 2006. Death rates from breast cancer are declining, however, particularly in women younger than 50, believed to result from increased awareness, better therapies and improved imaging detection. One of the newest imaging devices in the arsenal to fight breast cancer is the PET-CT scan.

What is a PET-CT scan?

PET-CT refers to a scanner that combines, during the same imaging session, positron emission tomography (PET) & computer tomography (CT). A combined (or hybrid) PET-CT scanner is currently held to be the most accurate way to stage and monitor many types of cancer including breast, colorectal, lymphoma, and lung among many others. PET is a Nuclear Medicine imaging study that uses short-lived radioactive tracers that localize in cancer cells.

PET scan is demonstrating recurrent advanced breast cancer disease to mediastinum, lungs, and liver. Areas of active tumor are evident as "hot" spots in the image.

Advances in molecular biology have established that certain cancer cells have increased glucose uptake and decreased glucose clearance. Glucose can be bound to a positively charged electron called positron to make the compound called 18 F-fluorodeoxyglucose (FDG). When injected into a patient's bloodstream, FDG is trapped by cancer cells allowing their visualization as "hot spots" on a PET scan. PET images can be overlaid or fused with the high-resolution anatomic images of a CT scan for a more precise localization of abnormal findings. The diagnostic accuracy of a hybrid PET-CT has been shown to be superior to that of the stand alone PET scanner, CT scanner, or MRI scanner. A PET-CT scan usually images the body from the head to the upper thighs. Because the brain uses glucose for metabolism, high background activity can mask small lesions, so PET-CT is therefore of limited value for diagnosing brain metastases.

The patient's blood sugar level affects tumor uptake on PET scans. With high blood glucose, tumor uptake of FDG may be decreased for which patients are asked to fast before the scan. Also, since muscles also use glucose for metabolism, patients are required to lie still for about 60-90 minutes after FDG injection. It is also necessary to curtail any vigorous exercise, including - but not limited to - jogging or weight lifting, for at least 48 hours prior to a PET scan as the fatigued muscles will continue to take up glucose for about 24 hours.

Benefits of PET-CT in Breast Cancer Patients

Since October 2002 and through the accrual of evidence based medicine, Medicare approved the use of positron imaging for patients with advanced breast cancer. At this time, PET-CT has not been approved for the initial diagnosis of breast cancer or staging of axillary nodes. Currently there are more than 500 medical journal articles documenting the clinical applications and benefits of PET & PET-CT in breast cancer, including the prestigious *New England Journal of Medicine* 2006 354; 496-507. The three Medicare approved indications of PET-CT in breast cancer patients currently are:

1. **Evaluation of metastatic disease**. Accuracy in staging and early identification of recurrent tumor is critical for therapy choice including avoidance of unnecessary surgeries. In advanced breast cancer patients, PET-CT is more accurate than other imaging modalities for identification of lymph node involvement to the mediastinum (the area around the heart and great vessels) and internal mammary nodal regions located at either side of the breast bone. PET-CT can also locate metastatic disease to lung tissue, liver, abdominal lymph nodes, and bone.

2. **Evaluation of recurrent disease**. In studies evaluating asymptomatic patients with rising serum tumor markers, such as CA 15-3 & CA 27-29., PET-CT has an accuracy of 87-90% in detecting sites of metastatic disease. Furthermore, in patients with negative serum tumor markers but suspicious clinical findings, PET-CT scanning appears to be more reliable than conventional imaging for identifying relapsed tumor.

3. **Assessment of therapy response at an early phase**. PET-CT renders it possible to identify patients responding to chemotherapy very early on, namely after one or two cycles of chemotherapy. Responders will show a rapid decline in FDG uptake in tumor cells, whereas non-responders will show little or no change in FDG uptake. Chemotherapy that is not working may be discontinued in non-responders and changed to a new chemotherapy protocol. 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.

The Future

Some research medical centers are testing dedicated breast PET-CT scanners or PET-Mammography units for the detection of small primary breast cancer as alternative ways for image guided biopsy of lesions suspicious for cancer. Current research in molecular oncology is geared towards other new imaging tracers that may further improve breast cancer detection with positron imaging. Potentially, molecular therapies that target specific cell receptors or processes may be tagged with a positron and imaged, thereby allowing not only imaging but also treatment in this novel fashion.