Molecular Breast Imaging (MBI) is an emerging radiotracer technique for detecting breast cancer, especially in women with radiographically dense breasts (about 40% of North American and European women; over 50% of Asian women). MBI uses an IV injection of 2-8 mCi of ^{99m}Tc-sestamibi (140 keV single gamma photon emissions, 6 hr half-life). Uptake in cancer lesions is rapid and imaging can begin within 5 minutes. Tracer washout is slow and uptake in normal tissue is much less avid. MBI evolved from scintimammography (SMM) which used a whole-body gamma camera to image the breast from a lateral position. Only lesions larger than 1 cm could be reliably detected by SMM because of the large distance from the collimator to the breast. MBI uses two small field-of-view gamma cameras in contact with the breast, which is mildly compressed between the two cameras to immobilize the breast during imaging. Typically two standard mammographic views are imaged for each breast: CC (cranio-caudal) and MLO (medio-lateral-oblique). The detectors for MBI are digital, solid-state, pixellated CZT (cadmium-zinc-telluride) modules. Multiple CZT detector modules are tiled to form a planar gamma camera. Pixel pitch is 1.5 mm (Gamma Medica LumaGEM) or 2.5 mm (GE Discovery 750b) and the crystal thickness is 5 mm. Energy resolution is typically 4.7% (LumaGEM) or 6% (Discovery). Closely related techniques include BSGI (Breast Specific Gamma Imaging) and PEM (Positron Emission Mammography). BSGI (Dilon 6800 or Acella) is an older, less-sophisticated form of MBI using 3.0-3.2 mm pixel scintillators (NaI or CsI) and either PS-PMT or APD photodetectors. BSGI also uses only a single detector. PEM (Naviscan) uses ^{18}F-FDG and coincidence detection (paired 511 keV gamma emissions, 2 hour half-life) using small scintillator/PMT detectors that physically scan side-to-side to form a limited-angle PET scan. Patient preparation is lengthy for PEM: 12-24 hour fast, 1-2 hour quiet uptake delay after injection.

This lecture will examine the physics of MBI, BSGI, and PEM and will compare the performance of the commercially available systems (all FDA 510(k) cleared). Patient and technologist radiation dose will be discussed. Clinical examples will be shown to demonstrate the application of MBI for secondary diagnosis and screening of radiographically dense breasts. Reimbursement issues will be briefly presented. MBI-guided biopsy procedures will be discussed. Several NEMA NU1 tests can be adapted to characterize the performance of the small-FOV planar gamma cameras of MBI and BSGI, and NEMA NU2 tests can be adapted for PEM. A new lesion contrast-detectability phantom is under development and its use to compare system performance will be discussed. Finally, the potential market for MBI equipment and procedures will be discussed and the prediction will be made that by 2020 MBI could challenge myocardial perfusion imaging (MPI) as the most frequently used nuclear medicine procedure.

Learning Objectives:

1. Understand the physics of MBI, BSGI, and PEM breast imaging.
2. Understand how radiation dose can be lowered in MBI, BSGI, and PEM.
3. Understand how to characterize the performance of MBI, BSGI, and PEM systems.