

Breast Specific Gamma Imaging (BSGI)/ Molecular Breast Imaging (MBI)



Rajchadara S, MD
email : samart.ra@bgh.co.th

Samart Rajchadara, MD¹

¹ Department of Oncology Imaging and Nuclear medicine, Wattanosoth Hospital, Bangkok Hospital Group, Bangkok, Thailand.

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Breast cancer is one of the most frightening cancers for women because of its high incidence: it is the most common cancer in Thai females. Genetic and environment are both important causative factors, especially the latter. Changing life styles, and increased use of drugs and food supplements have contributed towards the increasing incidence of breast cancer. Early detection of cancer may lead to successful treatment and a longer life span. Teaching women how to examine their own breasts is recommended worldwide to detect abnormal breast mass and cancer. However, the size of the lump, different examination techniques and density of the breast also play a role in detectability.

Mammography currently plays a major role in breast cancer screening. The sensitivity of screening mammograms in breast cancer detection is 85% or less; 68%, in denser breasts.¹ Nuclear medicine offers additional investigative options which may improve the accuracy of cancer detection. Techniques include breast scintimammography and most recently, Positron Emission Mammography (PEM). We have used the Technetium-99m 2-methoxyisobutylisonitrile (Tc-99m MIBI) breast scintimammography for many years with sensitivity ranging from 62%-95.8 % and specificity of 69%-100%.²⁻⁵ Dense fibroglandular breast tissue dose not decrease the sensitivity. However, small lesions, especially where the size is less than 1cm can directly reduce the sensitivity by 35% - 64%. This decreased sensitivity is directly affected by the properties of the collimator. The design of both general purpose and high sensitivity collimators do not generally allow for optimal breast imaging and prohibit the acquisition of standard mammographic views. The development of a high resolution, small field of view, breast-specific, gamma camera improves the sensitivity because this new machine can increase intrinsic spatial resolution and accessibility to the posterior and medial aspect of the breast and can decrease the high scatter radiation from nearby organs such as heart, liver and gall bladder. We can gently press this small gamma camera to the breast to minimize the distance between the breast and detector to improve the resolution.

Tumor imaging with Tc-99m MIBI was first reported in 1987.⁶ It is a molecular imaging tool for breast cancer detection, which takes advantage of the functional differences between normal and cancerous tissue. Although the exact mechanism of Tc-99m MIBI cellular uptake is not really known, *"it has been suggested that it may be related to factors such as passive diffusion, plasma membrane electrical potentials, mitochondrial index, and the lipophilic nature of MIBI."*⁷ So Tc-99m MIBI imaging has been used to detect various cancers such as lung cancer, osteosarcoma, brain tumors and some benign tumors such as parathyroid adenoma. Before the year 2000, diagnosis of breast cancer and recurrent

brain and lung tumor by using Tc-99m MIBI and Tl-201 chloride were extensively studied. However, in the early 21st century, more pilot studies on high-resolution scintimammography were reported. Brem RF⁸ found that BSGI provided better resolution and detectability of lesions than the conventional Single-photon emission computed tomography (SPECT).

The following indications are based on the guidelines for breast scintigraphy with Breast-Specific Gamma Camera 1.0 created by the Society of Nuclear Medicine (SMN) in 2010.

Indications

For patients with recently detected breast malignancy:

1. Evaluation of tumor extension in Staging. Some axillary node metastasis can be demonstrated with scintigraphy.

2. Detecting multicentric, multi-focal, or bilateral disease. (Brem et al⁹ reported that BSGI can detect additional suspicious lesions occult to mammography and physical exam in 29% of patients. In another study, 16.7% of patients have multifocal disease. Brem was able to detect an additional 7.2% of occult cancers, which were not seen at the mammographic study.¹⁰

3. Assess patient response to neoadjuvant chemotherapy.

4. Patients at high risk for breast malignancy.

- 4.1 Suspected recurrence such as differentiated recurrence of disease from scar.
- 4.2 Limited mammogram or previous malignancy was occult on mammogram.

5. Patients with indeterminate nature of lesion in breast and malignant is still suspicious.

- 5.1 Nipple discharge with abnormal mammogram and/or sonographic abnormality.
- 5.2 Bloody nipple discharge with normal mammogram.
- 5.3 Significant nipple discharge with unsuccessful ductogram.
- 5.4 Evaluation of lesions when patient reassurance is warranted (BIRADS 3).
- 5.5 Evaluation of lesions identified by other breast imaging techniques included palpable and non-palpable lesion.
- 5.6 Evaluation of palpable abnormalities not demonstrated by mammography or ultra-sound.
- 5.7 Evaluation of multiple masses demonstrated on breast imaging.
- 5.8 To aid in biopsy targeting.
- 5.9 Evaluation of diffuse or multiple clusters of microcalcifications.

5.10 Evaluation of breasts for occult disease in cases of axillary lymph node metastases with unknown primary.

5.11 Unexplained architectural distortion.

5.12 Evaluation of suspicious mammographic finding seen on one view only.

5.13 Evaluation of enhancing areas seen on magnetic resonance imaging (MRI) to increase specificity.

Breast Specific Gamma Imaging (BSGI) can also detect invasive lobular carcinoma, which is the second most common breast malignancy, accounting for about 10% of breast cancers and may be difficult to be detected by mammography. BSGI has the highest sensitivity for detection of invasive lobular carcinoma with sensitivity of 93%, whereas mammography, sonography and MRI showed sensitivity of 79%, 68% and 83% respectively.⁸

In cases of carcinoma in situ, BSGI is a powerful complimentary imaging for the detection of ductal carcinoma in situ (DCIS) with an overall sensitivity of 89.5 percent. In a retrospective study, 55 women with 57 biopsy-proven DCIS lesions were included. All patients had baseline BSGI then image findings were compared to the tissue study from biopsy or excision. The sensitivity for the detection of DCIS were calculated and correlated with size of the DCIS. Of the 38 cases of biopsy-proven DCIS in 34 women, 89.5 percent were detected with BSGI. The findings indicated that the pathologic tumor size of the DCIS ranged from 0.1-3.1 centimeters in 33 cases. BSGI had sensitivity for 1 centimeter or smaller DCIS of 90.5 percent and could detect DCIS as small as 1 millimeter. The sensitivity of BSGI detection of DCIS is comparable to that reported for MRI detection of DCIS (87.9 percent and 92 percent).¹⁰

6. Patients with technically difficult breast imaging:

- 6.1 Radiodense breast tissue.
- 6.2 Implants, free silicone, or paraffin injections compromising the mammogram.
- 6.3 Post surgical breast.

Dense breast tissue can reduce the sensitivity of cancer detection by mammography because of its high attenuation. The scintimammography has better detection rates because the gamma rays from Tc-99m MIBI can penetrate the dense breast very well. This causes higher sensitivity of cancer detection.

7. Patients for whom Breast MRI would be indicated:

- MRI is diagnostically indicated, but not possible
 - a. implanted pacemakers or pumps
 - b. ferromagnetic surgical implants
 - c. risk of nephrotoxicity from gadolinium
 - d. patients with breasts too large to be evaluated in a breast coil

- e. patients with claustrophobia
- f. other factors limiting compliance with a prescribed MRI study.

Lanzkowsky et al¹¹ reported the comparative study of indeterminate lesions detected on the breast by MRI whereby BSGI was able to correctly rule out the need for biopsy or follow up for 35% of cases, correctly identified necessary intervention in 12%, of cases, resulted in no change in management for 29% and accounted for unnecessary biopsy for 24% of cases.

A retrospective review published in 2010 by Brem et al showed BSGI detected additional suspicious lesions occult to mammography and physical exam in 29% of women (46 of 159) with one suspicious or cancerous lesion detected on mammography and/or physical exam. Breast biopsy or surgery demonstrated occult cancer in 35% of women who underwent biopsy because of findings on BSGI, which constituted 9% of all women.¹² Considering the advantages of BSGI over MRI, including cost, ease of study for patients, time of interpretation for radiologists, and the ability to image all women, BSGI is an effective imaging modality in the identification of occult breast cancer.

BSGI is more cost-effective than MRI and can be performed in all patients regardless of claustrophobia, renal insufficiency, metal/cardiac implants or patient weight.

8. Monitoring neoadjuvant tumor response in patients undergoing preoperative chemotherapy.

- 8.1 Determine the impact of therapy
- 8.2 Surgical planning for residual disease

Patient precautions

1. No special preparation for the test is needed.
2. Patient should be informed about BSGI process.
3. Known hypersensitivity to 99mTc-sestamibi is a contraindication, extremely rare.
4. Pregnancy is a contraindication
5. The date of last menses or pregnancy and lactation status of the patient should be determined.
 - a. BSGI should be performed between day 2 and day 12 of the patient's cycle if possible.
 - b. If pregnancy is possible, study should be delayed until onset of menses.
6. Ideally, BSGI should be performed prior to interventional procedures. Breast scintigraphy (BSGI) is commonly used in pre-surgical planning and can effectively evaluate

the remainder of the breast tissue in such cases. If performed within 2 weeks after a cyst aspiration/fine needle aspiration, or 3 to 4 weeks after a core or excisional biopsy, it can produce false positive results at the interventional site. This effect is less likely if imaging is conducted within the first 72 hours after needle procedures.

7. There was no significant difference in the likelihood of detection of occult cancer as a function of menopausal status, personal or family history of breast cancer, mammographic parenchymal density, index cancer pathology, or size.

Radiopharmaceuticals

1. 20 mCi of the radiopharmaceutical (Tc-99m MIBI) will be injected via venous catheter or butterfly needle followed by 10 ml of saline to flush the vein.

2. When possible, tracer should be administered via upper extremity vein on the opposite side of the breast with the suspected abnormality or via the peripheral vein of leg.

Protocol/Image Acquisition

1. Patient Position
 - a. The patient is seated for the entire scan. Image positions should duplicate standard mammographic views according to the most recent mammogram.
2. Imaging
 - a. Imaging begins 5-10 minutes after administration of the radiopharmaceutical.
 - b. Planar images are acquired for 10 minutes each or 175K, (7 minutes minimum)
 - c. Planar images should be acquired for each breast beginning with the side of the suspected.
 - d. Four standard views included right and left craniocaudal (CC), right and left mediolateral oblique (MLO)
 - e. Additional views which may be asked for by the interpreting physician include 90 degree lateral (LM and ML), axillary tail (AT), cleavage view (CV), exaggerated craniocaudal (XCC), implant displacement (ID), Right Antero-posterior View (axilla), Left Antero-posterior View (axilla).

As for the radiation dose, American people receive an average radiation dose of about 3 millisieverts (mSv) per year from the environment. (13) The average effective dose from two-view screen-film (0.56 mSv) or digital mammography (0.44 mSv) is equivalent to approximately two months of the natural background radiation, while the effective dose from BSGI and Computed Tomography (CT) scan of pelvis and abdomen are 6.2 and 10.0 mSv

respectively. In the recent RSNA meeting in 2011, Breast-specific gamma imaging was presented as having higher sensitivity and comparable specificity when compared with mammography and ultrasound in the diagnosis of breast cancer and can serve as an adjunctive test when the two other methods do not yield a clear diagnosis.

Currently, no one is advocating using the BSGI as a screening method to replace mammography. These exams are typically performed on women with suspicious breast lesions and in women with dense breasts who are difficult to examine with other techniques.

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