

Technical Aspects of Prone Dependent-Breast Scintimammography

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Objective: We describe the technical aspects of scintimammography for detecting breast cancer in patients with positive mammography or positive clinical findings.

Methods: Prone dependent-breast scintimammography was performed on 390 patients evaluated for the presence of breast cancer. Planar images were acquired beginning 5 min following intravenous injection of 20 mCi of ^{99m}Tc -sestamibi. Complementary imaging by SPECT was performed in 29 selected cases.

Results: The prone dependent-breast position was well tolerated by patients, and resulted in high-quality images with easily identifiable anatomic landmarks. The sensitivity of scintimammography was 96% and specificity was 85% in 62 lesions with pathologic correlation. Interobserver agreement was 96% and intraobserver diagnostic variability was <5% in the initial 137 patients studied.

Conclusion: The high ratio of lesion-to-background sestamibi activity and excellent separation of breast tissue from the heart and liver and anterior chest wall provides a reliable noninvasive means of breast cancer detection.

Key Words: scintimammography; breast cancer; technetium-99m-sestamibi

J Nucl Med Technol 1994;22:165-170

Breast cancer is the most common cancer among American women, including 150,000 new cases and over 44,000 deaths in 1990 (1). Successful treatment of breast cancer requires detection methods that can provide early and accurate diagnosis. Currently, the most effective method of detecting nonpalpable breast cancer is screening mammography. Mammography has a high sensitivity of 85%–90%, but correctly predicts malignancy in only 20%–30% of mammographically suspicious lesions (2,3).

Technetium-99m-sestamibi (Cardiolite™, DuPont Merck Pharmaceutical Company, No. Billerica, MA) has been used extensively for detecting myocardial infarction and ischemia

(4,5). A number of studies have recently reported its use in tumor imaging, including thyroid cancer, parathyroid adenomas, bone tumors and brain gliomas (6–9). In a series of 59 breast patients with pathology results for 62 lesions, we have reported a negative predictive value of 97.5%, a sensitivity of 96% and a specificity of 85% (10). The purpose of this paper is to describe the technical aspects of ^{99m}Tc -sestamibi prone dependent-breast scintimammography.

MATERIALS AND METHODS

Patient Population

We performed scintimammography on 390 patients (age 48.7 ± 10.1 yr, mean \pm s.d.). Of these patients, 387 were female and 3 were male. Each patient had a comprehensive physical breast examination in supine and upright positions by an experienced breast surgeon. Patients were referred for scintimammography for evaluation of a palpable mass or a suspicious finding on mammography. The masses evaluated ranged in size from 0.8 cm to 15 cm. There were 182 palpable masses and 222 nonpalpable masses seen only on mammography. Twenty female patients with a negative breast physical examination and a negative mammography were studied as normal controls. All patients gave their informed consent to a protocol approved by the Harbor-UCLA Medical Center Human Subjects Committee.

Mammography

Each patient had a bilateral mammography in the cranio-caudal and mediolateral oblique projections using a dedicated mammography unit (GE Senographe 600T, General Electric, Milwaukee, WI), as well as additional views of the abnormal areas using magnification and cone compression. All mammograms were read by an experienced radiologist with complete knowledge of the patient's history and clinical presentation, as well as the results of any available previous mammograms.

Radiopharmaceutical and Imaging Equipment

Each patient received 20 mCi (740 MBq) of ^{99m}Tc -sestamibi (MIBI) injected intravenously in the arm contralateral

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to the breast with the abnormality. A butterfly needle connected to a three-way stopcock and a 10-cc saline flush or an indwelling intravenous catheter was used to eliminate infiltration.

Scintimammography was performed using a rectangular-head gamma camera (SophyCamera DSX, Sopha Medical, Columbia, MD) equipped with a high-resolution collimator. Patients were imaged prone using a plastic table overlay (Bodfish Research and Design, Bodfish, CA) which allowed the breast being imaged to be freely dependent from the imaging table (Fig. 1). Five additional patients were imaged supine with the breasts taped superiorly. Four patients were imaged in both prone and supine positions. Supine and upright images were acquired using a 20% window centered at 140 keV. For prone imaging, the spectrometer was centered at 140 keV with a 10% window to reduce scatter from the imaging table.

Prone Imaging

A 10-min prone lateral image of the breast with the suspected lesion was begun 5 min postinjection. If a lesion was seen near the chest wall on the lateral image, a 30° posterior oblique image was acquired without moving the patient. The patient was repositioned with the contralateral breast dependent, and a lateral image was acquired. An acquisition zoom factor of 2.0 was used for the lateral images to allow inclusion of the largest breast size encountered, as well as the anterior chest wall. This allowed exclusion of most of the

activity from the chest and abdominal organs such as the liver, gallbladder and myocardium. A final 10-min anterior chest image was acquired in the upright position with the patient's arms raised for visualization of the axillae.

Supine Imaging

For supine imaging, the patients' breasts were taped superiorly to maximize separation of the breast tissue from the myocardium and liver. Ten-minute lateral images of the

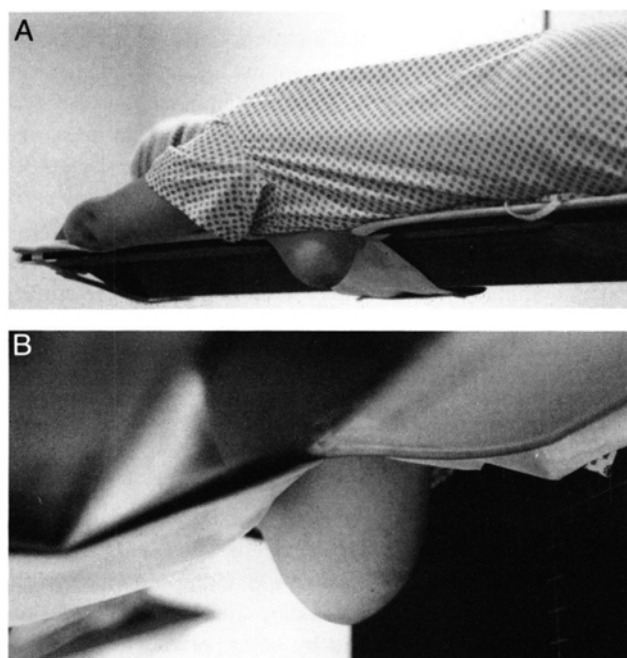


FIGURE 1. Patient position for left lateral prone dependent-breast scintimammography image. A plastic overlay is attached to the tomography table. (A) The view from the left shows the patient's arm and pelvis are supported while allowing the left breast to be freely dependent from the imaging table. (B) View from underneath with the detector in place. The collimator face is positioned touching the patient's left side. Tomography is also performed in this position, with the lesion centered in the field of view.

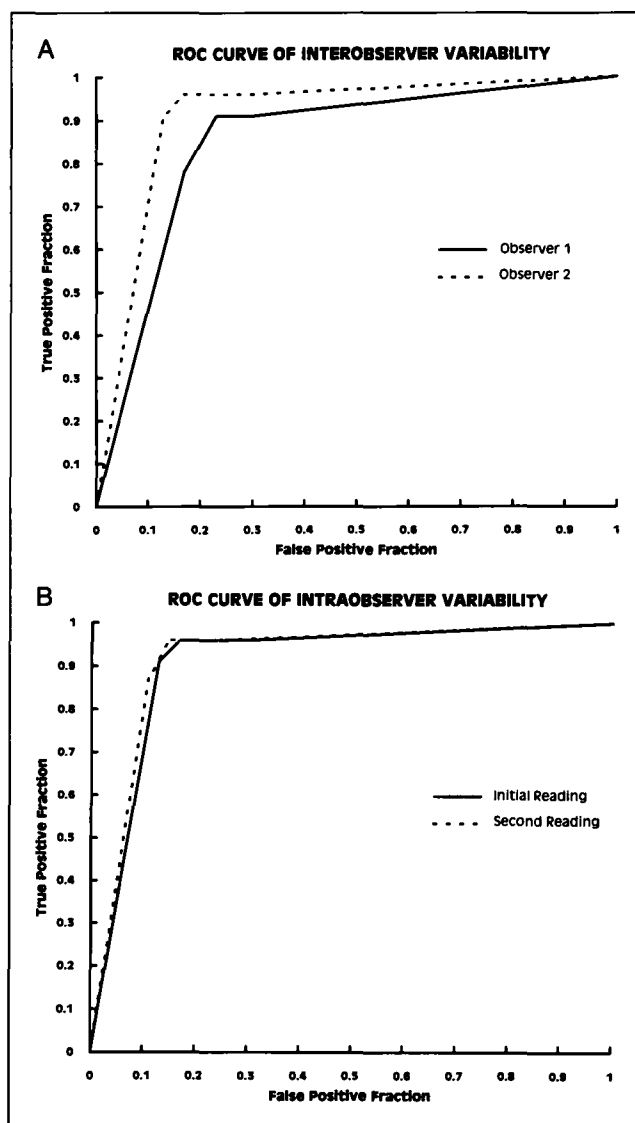


FIGURE 2. Receiver-operating characteristic (ROC) curves of decision performance for 62 breasts with pathologic correlation. The curves show true-positive fraction (true-positive decisions divided by all actually positive breasts) versus false-positive fraction (false-positive decisions divided by all actually negative breasts) based on five possible decision thresholds ranging from definitely negative to definitely positive. (A) Curves based on performance of two observers show excellent agreement with a high degree of diagnostic accuracy. (B) Curves based on two readings 9 mo apart by a single observer show a very slight improvement in accuracy with experience.

breasts were acquired beginning 5 min postinjection, followed by a supine anterior image with the patients' hands placed behind their head.

SPECT

Lesions detected on the prone lateral images in 29 patients were further evaluated using SPECT. The patient remained in the prone position with the breast dependent. Data were acquired over a 180° rotation, from a 45° anterior oblique to a 45° posterior oblique projection. Thirty-two 30-sec frames were acquired using a 64 × 64 matrix. The reconstructed transverse, coronal and sagittal images were displayed in gray scale, with postacquisition masking of the chest and abdominal organs as necessary.

Data Analysis

All images were evaluated for abnormal ^{99m}Tc -sestamibi uptake by two experienced nuclear medicine physicians (I.M. and I.K.) blinded to the patients' clinical presentation

and mammographic results. A focal area of increased uptake in the breast was considered positive. Mild diffuse increased uptake or no area of increased MIBI uptake was considered negative for malignancy. Regions of interest (ROIs) were created over the area of focal sestamibi breast uptake seen on the prone lateral images and an adjacent area of normal breast tissue, and target-to-background activity ratios were calculated. Results of scintimammography were correlated with excisional biopsy or fine-needle aspiration cytology. Supine and prone lateral images were evaluated for ease of breast tissue visualization, as well as lesion identification in images with focal increased MIBI uptake.

Prone lateral images were used to determine image reproducibility in eight patients referred for a second study following surgery and radiotherapy or chemotherapy for a malignant lesion seen on the initial scintimammogram. The average time interval between the initial and post-treatment studies was 7 mo. Intraobserver variability was determined

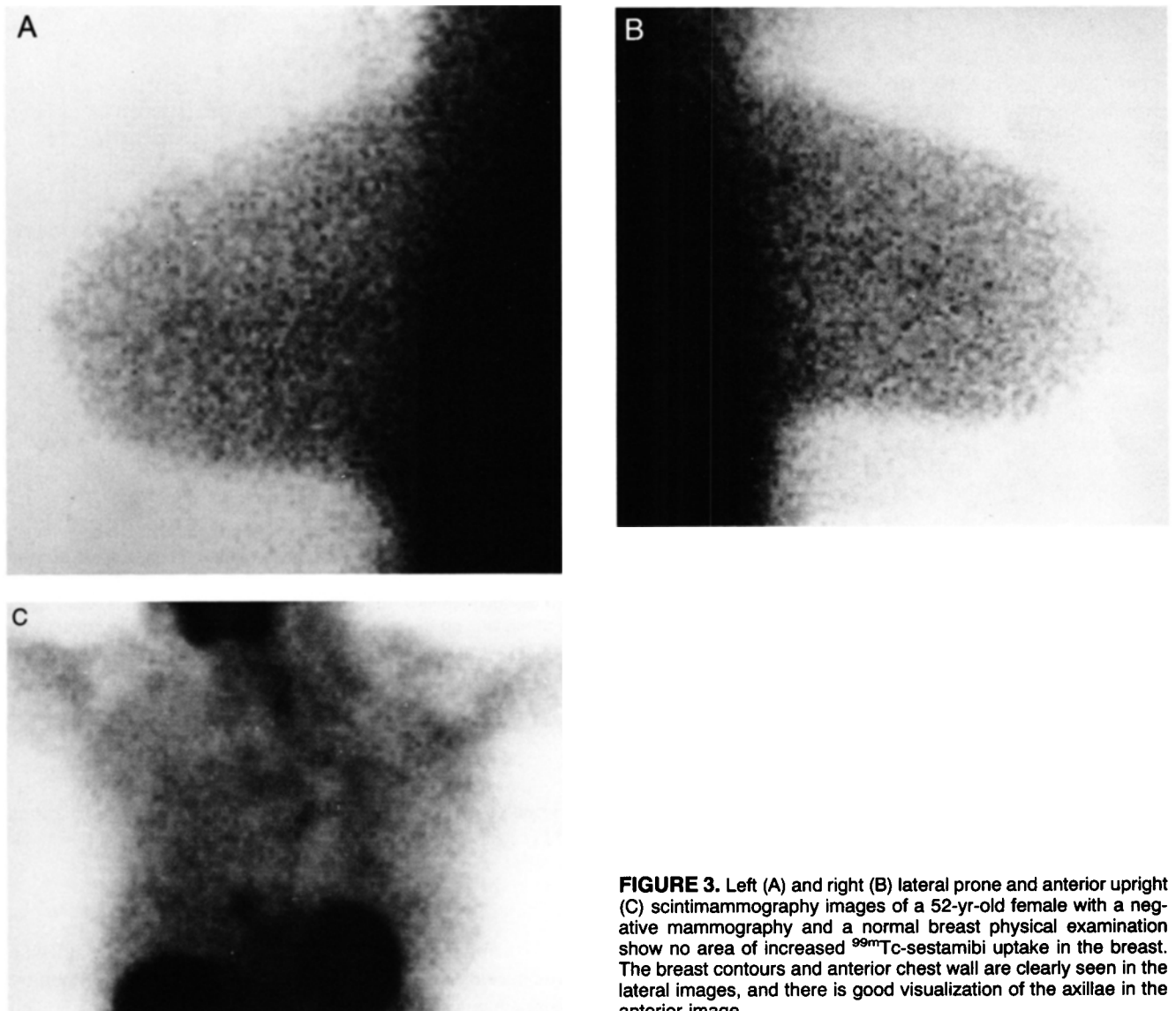


FIGURE 3. Left (A) and right (B) lateral prone and anterior upright (C) scintimammography images of a 52-yr-old female with a negative mammography and a normal breast physical examination show no area of increased ^{99m}Tc -sestamibi uptake in the breast. The breast contours and anterior chest wall are clearly seen in the lateral images, and there is good visualization of the axillae in the anterior image.

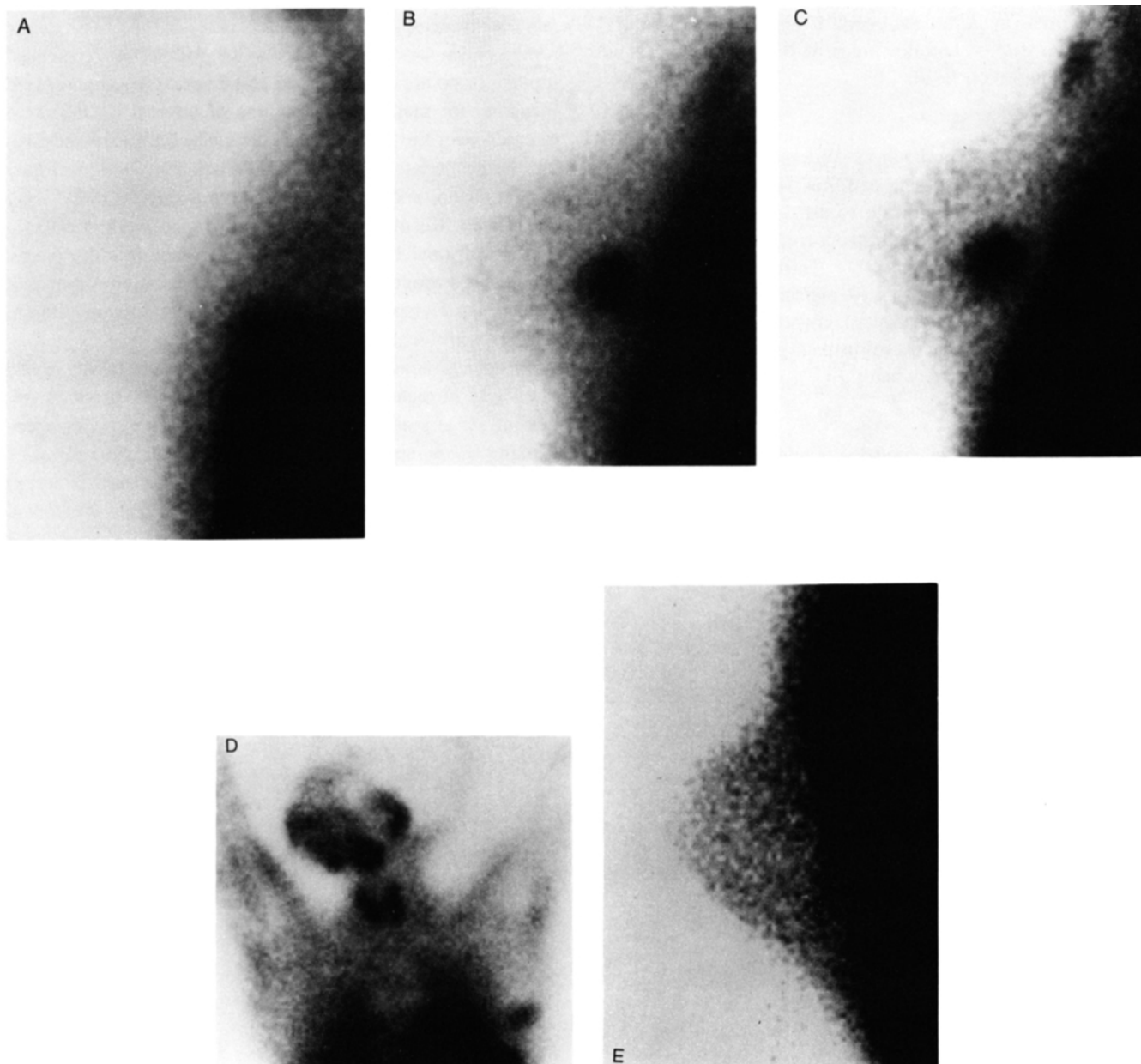


FIGURE 4. Supine left lateral (A), prone left lateral (B), 30° prone posterior oblique (C), and anterior upright (D) scintimammography images of a 33-yr-old female with a 3.5-cm palpable mass in the left breast, which was mammographically indeterminate, show a focal area of increased uptake. Due to its partial superposition of the myocardium, the lesion is difficult to characterize in the supine image. The prone dependent-breast position allows better separation of the breast tissue from the myocardium, so the entire border of the lesion is easily seen on the prone lateral image. This deep lesion is better separated from the chest wall on the posterior oblique image. The biopsy result was medullary carcinoma. The patient returned for scintimammography 4 mo later, following lumpectomy and radiation therapy. The post-treatment prone left lateral image (E) shows no area of abnormal MIBI uptake.

using a second blinded reading of 137 patients (270 breasts) by a single reader (I.K.) 8 mo following the initial evaluation. Using a method described by Metz, receiver-operating characteristic (ROC) curves were created from interobserver and intraobserver variability data for 62 breasts with pathologic results. Each breast was classified as definitely positive, probably positive, equivocal, probably negative or definitely negative. The decision threshold for a positive test was then

varied to create an ROC curve for each set of observations (11).

RESULTS

Both nuclear medicine physicians agreed that breast tissue was better visualized by the prone imaging protocol than by supine images. The prone dependent-breast position allowed

relaxation of the pectoralis muscle, resulting in good separation of the breast tissue from the chest and abdominal organs. The natural breast contours seen in prone imaging also functioned as anatomic landmarks for lesion localization.

The ratio of ^{99m}Tc -sestamibi activity in positive lesions compared to adjacent normal breast tissue ranged from 1.3 to 5.8. There was no significant difference in the target-to-background activity ratio in lesions identified as cancer by pathology (true positives) compared to that in benign masses (false positives).

Interobserver agreement was 96% in the initial 137 patients enrolled, with the majority of the disputed readings in patients who exhibited bilateral symmetrically increased sestamibi uptake. Intraobserver variability was 5% in 270 breasts. Two breasts with initial false-positive results (based on biopsy) were read as true-negative on the second reading. At the time of the initial reading, three breasts were classified as indeterminate, but all were classified as positive or negative at the second reading 8 mo later. ROC analysis of the 62 breasts with pathologic findings shows both observers maintain a high true-positive fraction and low false-positive fraction at all intermediate decision thresholds (Fig. 2).

Lateral images of the normal breast in eight patients referred for post-treatment evaluation exhibited complete reproducibility when compared to the initial study. Additionally, increased sestamibi uptake was not seen in the breasts treated by surgery, radiation or chemotherapy.

One unexpected difficulty in performing prone dependent-breast scintimammography was the low-energy scatter from the table material, which frequently appeared as a vertical line through the breast and occasionally interfered with the interpretation of the image. This artifact was minimized by decreasing the 140-keV photopeak window from 20% to 10%, and by positioning the patient's chest and shoulder flat against the table.

Activity from soft-tissue infiltration of the intravenous sestamibi injection appeared in the axillary lymph nodes or along the arm vessels, making evaluation of axillary metastases difficult. This problem was resolved by using a butterfly needle, three-way stopcock and 10-cc saline syringe as a "cold-start" injection system. To further minimize the possibility of the axilla being unevaluable, the injection was performed in the arm contralateral to the breast with the suspected lesion whenever possible.

DISCUSSION

Prone imaging of a single dependent breast provides maximal separation of breast tissue from the myocardium and liver, as well as exclusion of any activity present in the opposite breast. The natural breast contour and anterior chest wall are easily visualized on the lateral images, providing anatomical landmarks for lesion localization (Fig. 3). Deep lesions are better separated from the chest wall in the

30° posterior oblique image (Fig. 4). A successful intravenous injection is important, as infiltrated ^{99m}Tc -sestamibi tends to collect in the arm vessels, as well as the axillary lymph nodes.

Prone dependent-breast scintimammography is technically simple to perform, although care must be taken that no breast tissue is compressed against the imaging table. Images must also be displayed using adequate contrast, since the uptake of MIBI in normal breast tissue is minimal compared to that in the myocardium and abdominal organs. The prone position is generally well tolerated by the patient, especially if the technologist explains the procedure and provides adequate safety and privacy. It is particularly important that the imaging table is locked securely in place with the detector face touching the patient's side, and the technologist remains with the patient during the entire prone imaging procedure.

CONCLUSIONS

In summary, prone dependent-breast scintimammography using ^{99m}Tc -sestamibi offers a noninvasive means of breast cancer detection. The high sensitivity and specificity of scintimammography make it a reliable test for further evaluation of lesions found by a physical breast examination or a screening mammography (10). The high lesion-to-background activity ratio and ease of breast visualization result in high-quality images. Prone dependent-breast scintimammography is simple to perform and is well tolerated by most patients. For optimal results, careful attention must be paid to patient positioning and image display.

ACKNOWLEDGMENTS

The authors thank Rosemary Kerwin, PharmD, for assistance in the preparation of this manuscript. This study was partially supported by a grant from the DuPont Merck Pharmaceutical Company.

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