The Role of Thallium Scintimammography with Lateral Decubitus Positioning in the Diagnosis of Breast Cancer

J. Hunt-Mozgala, E.R. Conklin, E.T. Cancroft, G.J. Wasserstein, J.W. Weitz, J.S. Deitch, Z.H. Oster, C. Cabahug and P.A. Bardfeld

Division of Nuclear Medicine, Department of Radiology, Nassau County Medical Center, East Meadow, New York; and Division of Nuclear Medicine, Department of Radiology, State University of New York Health Science Center at Stony Brook, Stony Brook, New York

Objective: Many different positioning techniques have been attempted in the search for the best method of imaging the breast during scintimammography. A new, effective and comfortable method of positioning the breast is described. Thallium-201-chloride is further explored as an agent to detect breast cancer.

Methods: Forty-two women with either a palpable mass or abnormal mammogram were imaged in the lateral decubitus and anterior supine positions. Each patient was injected intravenously with 75–112.5 MBq (2-3 mCi) of ^{201}Tl-chloride. Planar images of 10–15 min each were obtained beginning 10 min after injection.

Results: Lateral decubitus positioning was very comfortable for the patient and afforded maximum privacy. High-quality images were obtained with breast tissue and axilla clearly visualized. Breast-to-camera distance was minimized to less than 0.5 inch in many cases. The sensitivity of thallium scintimammography was 90% and the specificity was 86% in 26 lesions with pathologic correlation. The smallest lesion detected measured 0.8 cm.

Conclusion: Lateral decubitus positioning in scintimammography provides an alternative to prone positioning which is sensitive, comfortable and private. Thallium-201 scintimammography employing lateral decubitus positioning has an acceptable sensitivity and specificity for detecting breast carcinoma.

Key Words: scintimammography; thallium-201; breast cancer

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Breast cancer is the most common form of cancer in American women with an estimated 182,000 new cases in 1995. Breast carcinoma is the second leading cause of cancer deaths in women with an estimated 46,000 deaths in 1995 (*1*). Mammography is accepted as the most effective method of screening for early breast cancer. Mammography is limited, however, in that it misses 10–15% of cancers (*2,3*). Furthermore, the specificity of mammography is low with only 20–30% of lesions biopsied positive for carcinoma (*4,5*).

There is clearly a need for a new, noninvasive diagnostic test to augment mammography in the diagnosis of breast cancer. To bridge this diagnostic gap, many investigators have used radionuclides to detect breast cancer and to help differentiate benign from malignant lesions (*6–22*). Thallium-201 is currently widely used to detect myocardial infarction and ischemia. In a number of studies, ^{201}Tl has been shown to concentrate in tumors of the thyroid, parathyroid, brain and lungs in addition to lymphoma and osteogenic sarcoma (*12,23–28*). Thallium-201 also has shown promise as an agent to detect breast carcinoma (*12–18*).

It has become a challenge for technologists performing nuclear breast imaging to develop techniques that adequately image breast tissue. Unlike the mammography unit, gamma cameras are not exclusively designed to image the breast. It is difficult to duplicate the positioning techniques that are used in conventional mammography when using a gamma camera. Due to the collimator rim and the housing of the gamma camera, the first several inches along the perimeter of the detector head are not useable for imaging when using a gamma camera equipped with a parallel hole collimator. Several inches of tissue closest to the chest wall are missed in nuclear imaging in the craniocaudal and mediolateral oblique positions. It follows that in small-breasted women, most breast tissue is excluded. Furthermore, there is a need to distinguish between activity in breast tissue from activity arising from chest wall and organs, such as the liver and the heart.

To date, several imaging techniques and positions have been used to image the breast with a gamma camera. Lateral prone, anterior upright and supine, RAO and LAO supine, and supine SPECT imaging have been reported (*10,11,14,15,19–22*). Craniocaudal positioning using a small field-of-view camera

For correspondence or reprints contact: Jacqueline Hunt-Mozgala, CNMT, Division of Nuclear Medicine, H801, Nassau County Medical Center, 2201 Hempstead Turnpike, East Meadow, NY 11554.

equipped with a diverging collimator has been recently reported (*18*). We imaged patients in the anterior supine position. Furthermore, we imaged patients in the lateral decubitus position. Lateral decubitus imaging, with the patient lying on her side and the camera positioned under the imaging table, was developed in our institution initially in 1973 (*9*). Because we had experience and good results from lateral decubitus imaging, we chose this position in addition to the anterior supine position to do the study. We did not attempt prone positioning for the lateral view because we did not have the special table needed to do prone imaging.

In May 1992 one of the co-authors received a grant from DuPont Merck to study patients with breast carcinoma using ^{201}Tl. Within the next two years, there were both formal and informal reports that sestamibi was a superior agent for breast imaging. Although there was a temptation to abandon ^{201}Tl entirely, the decision was made to continue our ^{201}Tl project because we had made a committment and we wanted to study a significant number of cases. In addition, we had no additional funding for sestamibi research.

This article describes the technical considerations of lateral decubitus breast imaging and further evaluates the role of ^{201}Tl as an agent to detect breast cancer in comparison to mammography and breast biopsy.

MATERIALS AND METHODS

Forty-two women aged 32 through 97 yr (mean age of 59.3 yr) from two institutions were entered in our study. The entry criterion was either a palpable mass or an abnormal mammogram. This research project was approved by the institutional review boards of the two participating medical centers. Informed consent was obtained from all patients after a full explanation of the nature of the study. Normal controls were not used in our study because the institutional review board at our hospital would not allow the inclusion of such patients. The patients were intravenously injected in the arm with 75–112.5 MBq (2–3 mCi) of ^{201}Tl-chloride. Imaging was started 10 min after injection. Lateral decubitus views of each breast were obtained for 10 min each with the patient lying on her side on the imaging table and the camera under the table. Markers were placed at the level of the nipples, but not touching the breast. Lateral views were followed by a 15-min anterior supine view of both breasts. The anterior view was acquired for more time in order to obtain increased counts from the breasts because of significant cardiac activity in this view.

IMAGING PARAMETERS

An LFOV gamma camera (DS7, SMV America, Twinsburg, OH) equipped with a low-energy all-purpose collimator was used to image our patients. A matrix size of 256 × 256 words and a ^{201}Tl uniformity matrix was used. Energies were set at 70 keV and 167 keV, both with a 25% window. No zoom was used. Lateral views were obtained for a preset time of 600 sec. A single anterior view was obtained for a preset time of 900 sec.

PATIENT POSITIONING

Patient comfort and privacy were a main concern since breast imaging is potentially embarrassing and uncomfortable for both mammography and breast scintigraphy. Furthermore, most of our patients were experiencing considerable anxiety because, in most cases, they had just been informed that they had abnormal mammograms and/or physical exams that warranted biopsy. Since our pictures took a relatively long time, it was important to minimize artifacts caused by patient movement by making the patient as comfortable as possible.

Before injection, our patients were asked to undress from the waist up. They wore two hospital gowns: one opened in the front and one opened in the back to allow maximum privacy. Since imaging began within 10 min after injection, changing before injection saved time during setup and positioning.

The gamma camera was brought up flush under the imaging table. The mattress was removed and the table was covered with a sheet. This allowed increased resolution by bringing the breast closer to the camera. Using an XYZ imaging table with a clear acrylic surface aided positioning because it was easy to see when the breast was centered in the camera's field of view. The patient was placed on her side beginning with the side that had the suspected lesion. Folded blankets were placed under the patient's hip and head for comfort. The patient's knees were bent for both stability and comfort. The patient's arm was then raised near her head so it would be out of the way of the breast being imaged. The axilla was included in the field of view. Lead sheeting was placed under the patient's abdomen to provide shielding of activity from the liver and other organs. In order to remove activity from the contralateral breast, the patient rolled backwards slightly. A rolled up blanket was placed against the patient's back for support. The patient was asked to hold the nonimaged breast out of the way with her free hand (Fig. 1A). The breast being imaged was positioned away from and perpendicular to the chest wall. This position resulted in an image that was comparable to the mediolateral view of the mammogram. A ^{57}Co point source was placed at the level of the nipple, but not touching the breast. The breast positioned this way allowed for maximum resolution because it was extremely close to the camera; only the acrylic table (thickness = 0.25 in) and the sheet separated the breast from the surface of the camera (Fig. 1B). In small-breasted women, a folded towel was placed under the breast so that the position approximated the mediolateral view of the mammogram.

Once the patient was positioned for this lateral decubitus view, a 10-min picture was started. When completed, the patient then turned onto her opposite side and a 10-min view of the contralateral breast was obtained.

A 15-min anterior view was obtained with the patient supine. Both axilla and both breasts were included in the field of view. In large patients, two anterior views were necessary to include both axilla and all breast tissue. Patients who were able to do so raised their arms over their heads. A lead shield was placed over the patient's abdomen to minimize activity coming from the liver and other internal organs. Movement during the anterior view was minimized because the patient was lying

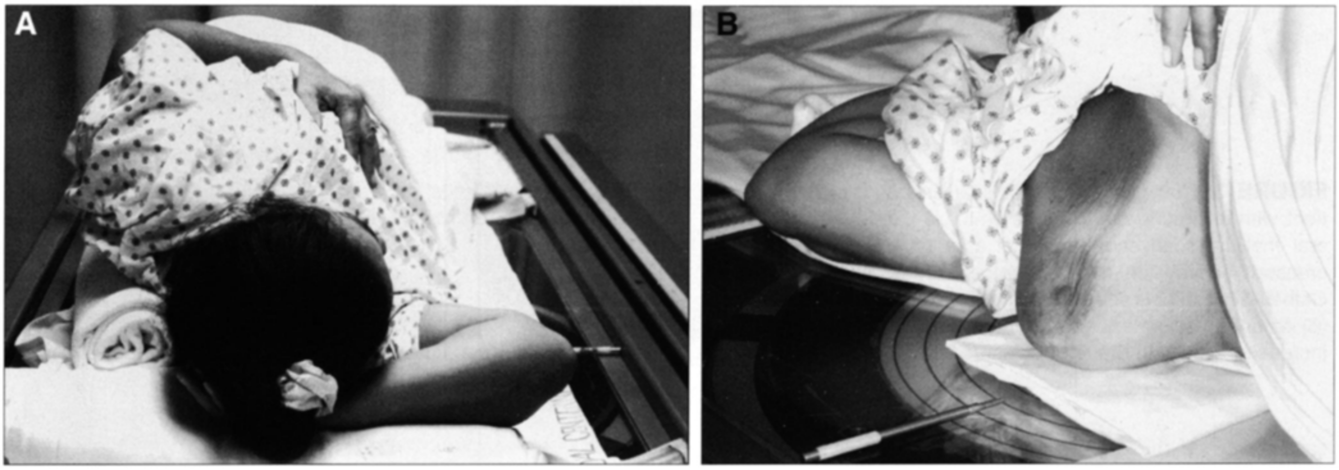

FIGURE 1. Patient position for lateral decubitus image of the breast. (A) The patient lies comfortably on her side with the camera positioned under the imaging table. This position allows for maximum comfort, privacy and warmth. (B) Resolution is maximized by having the breast as close as possible to the camera. In the lateral decubitus view, breast tissue can be positioned to within 0.5 in of the collimator face. The breast is positioned away from the chest wall, allowing separation of activity arising from chest wall, liver and myocardium. A ^{57}Co marker is used to mark the location of the nipple. Covers are removed for illustrative purposes.

comfortably on her back, fully supported by the imaging table, rather than sitting upright with minimal support.

RESULTS

Lateral decubitus positioning, with the patient lying on her side, is a very comfortable position, much like a sleeping position. This imaging technique allowed for maximum privacy and warmth since, once positioned, the patient was covered with a sheet and hospital gown during the entire imaging time.

High-quality images were obtained with all breast tissue and axilla clearly visualized. Breast tissue was well separated from chest wall, liver and other internal organs. Although the heart was visualized on the thallium breast scans, the presence of cardiac activity did not cause any significant problems in interpretation. A normal lateral view of the breast is seen in Figure 2A and a normal anterior view of the breast is shown in Figure 2B.

Resolution was maximized by having the breast as close as possible to the camera surface. The mattress was removed and only the thickness (0.25 in) of the acrylic of the imaging table and the sheet separated the breast from the gamma camera. Abnormalities were clearly shown and stood out from normal breast tissue with a high target-to-background ratio. A true positive thallium breast scan in a patient with infiltrating ductal carcinoma is seen in Figure 3A and B. Several patients had uptake in the axilla which was positive for lymph node metastasis on biopsy. Increased uptake in the left axilla and the upper quadrant of the left breast is seen in the anterior view in Figure 4A and in the lateral view in Figure 4B. This area corresponded to an axillary lymph node mass that was positive for carcinoma on biopsy. The lateral decubitus view aided in the intrepretation in two ways. It confirmed positive sites found on anterior views. Furthermore, in at least one patient, the anterior view was equivocal but in the lateral decubitus view a lesion was clearly shown (Fig. 5A and B). The patient was positive for carcinoma on biopsy.

The findings of our study are summarized in Table 1. Twenty-nine of 42 patients in our study had pathologically confirmed

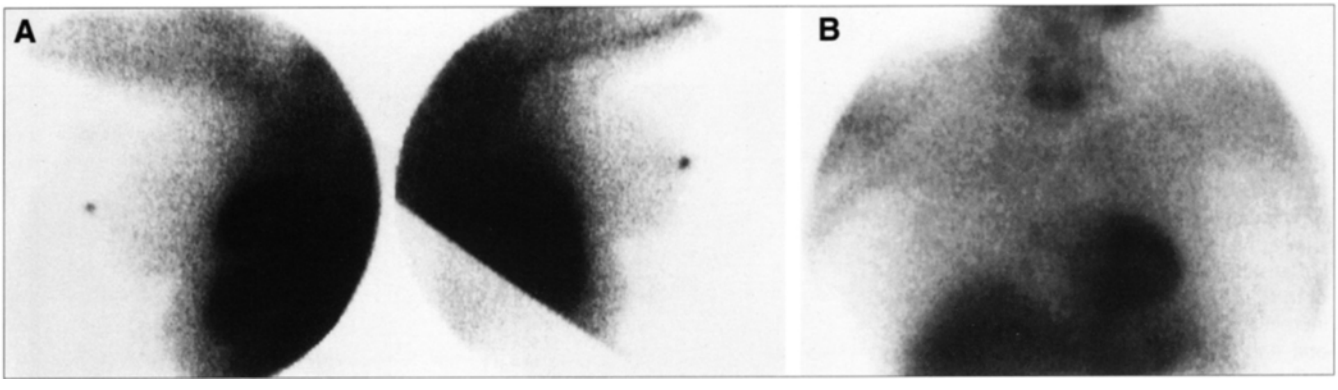

FIGURE 2. A normal thallium breast scan. (A) Lateral decubitus images of the left and right breasts show no evidence of any abnormal focus of increased ^{201}Tl activity. Radioactive ^{57}Co markers were placed anterior to the nipples. (B) Anterior image of the breasts show normal thallium distribution in the myocardium, liver and thyroid gland, as well as in the salivary gland.

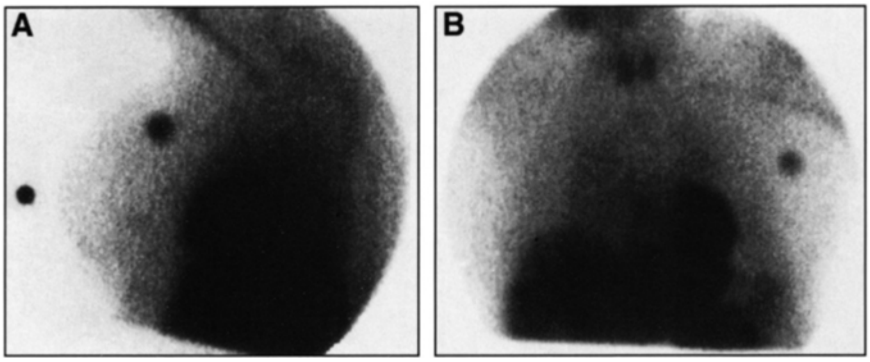

FIGURE 3. True positive breast scan in patient with infiltrating ductal carcinoma. (A) Lateral thallium scan shows a focal area of increased activity in the left upper breast. Colbalt-57 marker is seen anterior to the nipple. (B) Anterior thallium scan shows a focal area of increased activity in the left upper breast.

carcinoma. Of these 29 women, 26 had positive thallium scintigrams (true positive), resulting in a sensitivity of 90%.

Activity was seen in the lateral view in all patients with true positive studies. In 82% of the true positive cases, the lateral view clarified information. Furthermore, in those true positive cases, 82% had focal activity on both the lateral and anterior views. In those cases that did not have focal activity on both views, one case had diffuse activity on both the lateral and anterior views and the other case had focal activity on the lateral view only (Nassau County Medical Center data only). When activity was clearly identified on one view only, the lesion was found either on a mammogram, or it was found because it was palpable.

In the three patients that had false negative scans, one had a nonpalpable ductal carcinoma, another had a palpable adenocarcinoma (there was not enough tissue from fine needle aspiration (FNA) biopsy to tell what type of adenocarcinoma) and a third had a palpable ductal carcinoma. Of the remaining 14 women with benign disease, established by FNA, 12 had negative ^{201}Tl scans (true negative), leading to a specificity of 86%. Two patients had false positive scans. Of the two patients that had false positive scans, one patient had a fibroadenoma that exhibited moderate focal activity on scintimammography and the other had fibrocystic disease that appeared as mild focal activity on scintimammography.

The positive predictive value was 93% and the negative predictive value was 80%. The smallest lesion detected was 0.8 × 0.3 cm.

DISCUSSION

Many investigators have used radioisotope-based techniques to detect breast cancer and to help differentiate benign from malignant lesions (*6–22*). Results have been very promising, with specificity in most studies, including ours, ranging from 85% to 100% and sensitivity ranging from 80% to 96%. These results are more specific for breast cancer than mammograms (specificity 10%–30%) (*4,5*) and in some studies, are more sensitive than mammograms (sensitivity 85%–90%) (*2,3*).

Investigators using radionuclides routinely acquire an anterior view of the breasts, whether supine or upright (*10,11,14,15,18,19,21,22*). To increase sensitivity, a second view is usually performed. Recently, LAO and RAO views have been used (*11,14*). Lateral prone positioning and prone SPECT have also been used with success (*10,15,19,21,22*). Some investigators believe that lateral prone positioning may help visualize small lesions (<0.7 cm) (*11*). Others dispute the importance of prone positioning and state that it is speculative to suggest that prone imaging is the best technique without performing comparison studies of different positioning techniques (*29*). Maurer et al. used a small field-of-view camera equipped with a diverging collimator to image the breast in a craniocaudal position (*18*). Although this position minimized breast-to-camera distance, significant scatter from the heart and abdomen significantly increased background breast activity.

Lateral decubitus imaging, with the patient lying on her side, may have several potential advantages when compared to imaging in the prone position. In prone positioning, a plastic table

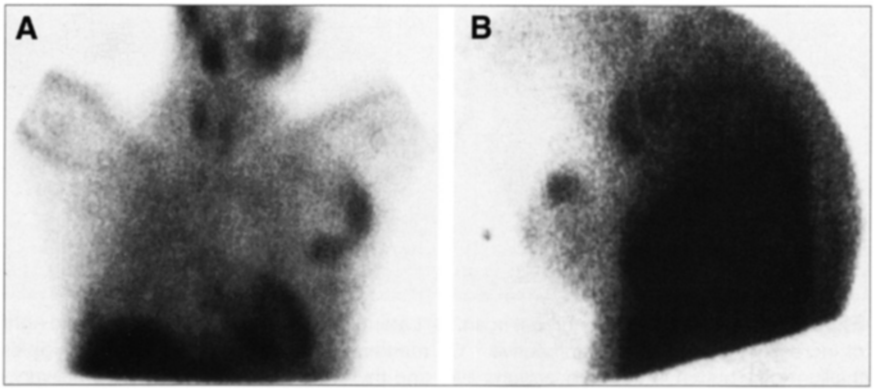

FIGURE 4. True positive breast scan in a patient with infiltrating ductal carcinoma with axillary metastasis. (A) Anterior view of the breasts with arms raised shows an abnormal focus of increased activity in the upper outer quadrant of the left breast. There is a contiguous area of increased activity which extends from the lateral end of this focal uptake toward the left axillary region which corresponds to a left axillary lymph node mass. (B) Lateral decubitus view of the left breast shows an abnormal focus of increased activity in the upper quadrant.

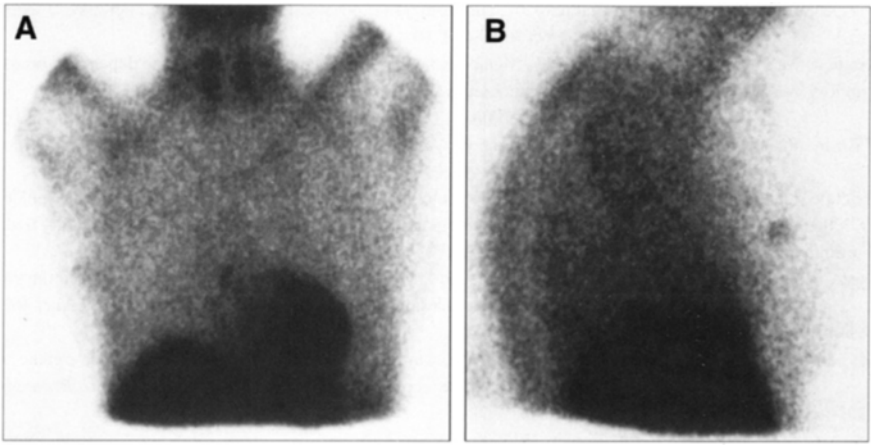

FIGURE 5. Patient with carcinoma of the breast in upper outer quadrant of right breast. (A) Anterior view of the breasts with equivocal uptake of ^{201}Tl in the region of the upper outer quadrant of the right breast. (B) Lateral decubitus view of the right breast shows a moderate focus of increased activity in the region of the upper outer quadrant of the right breast. The clarity of the abnormal focus in the lateral decubitus view made a correct interpretation of this thallium scintimammography possible.

overlay with a cutout for the breast is attached to the tomography table (*19*). Lateral views are taken in the prone position with the breast positioned so that it protrudes through the cutout in the plastic table. The patient's arm is raised high over her head and the gamma camera is positioned to the side of the patient. The lateral decubitus position is a more comfortable patient position than lying prone with arms raised high over her head. For patients who are unable to lie prone due to increased body weight or other factors, and for patients who are unable to raise their arms high over their heads, lateral decubitus positioning is preferable to lateral prone positioning. In addition, we believe that it is reasonable to assume that for some women the lateral decubitus positioning is less embarrassing than prone positioning because the breast is always covered during imaging and because the breast is not protruding through a hole in the table. No special equipment or table insert is needed to perform lateral decubitus imaging.

Clear, high-quality images of the breast are obtained using lateral decubitus positioning. The breast is separated from the chest wall. Resolution is maximized in this position because the breast is very close to the camera. In the lateral decubitus view, it is possible to have breast tissue located less than 0.5 in from the collimator face. The sensitivity of detecting breast cancer is high (90%) using this technique.

Sensitivity is one of the indicators of the effectiveness of position and imaging technique (*20*). Comparing our study (sensitivity 90%) to two recently published ^{201}Tl breast scintimammography studies, our results fell within the ranges reported by Waxman (sensitivity 96%) (*14*) and by Lee (sensitivity 80%) (*15*). Our data differed from data from prone sestamibi breast imaging reported by Khalkhali (*10,22*). Although specificities were about equal, Khalkhali reported higher sensitivities (96%, 93.7%). These differences may be due to multiple factors including positioning technique, the radiopharmaceutical used, and the patient population selected.

Because positioning is only one of several factors affecting sensitivity, a new study needs to be done comparing the sensitivity of different views using the same patients injected with the same radiopharmaceutical. This will make it possible to determine which views are best for imaging the breast and to develop standardized protocols for breast scintimammography.

Thallium-201 breast scintimammography can be considered to have an acceptable sensitivity and specificity for breast scintigraphy. Furthermore, ^{201}Tl offers the promise of supplementing the mammogram as a useful diagnostic adjunct for breast carcinoma. If sestamibi proves to be the agent of choice for the future, then it will also be important to know which is the best position for imaging with this radiopharmaceutical.

TABLE 1
Comparison of Thallium-201 Scans and Breast Biopsy Results.

	Breast cancer	Benign	Total
Thallium (+)	26	2	28
Thallium (−)	3	12	15
Total	29	14	43

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