

Technetium-99m-MIBI scintimammography by planar and SPECT imaging in the diagnosis of breast carcinoma and axillary lymph node involvement

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Abstract

BACKGROUND: We compared SPECT and planar ^{99m}Tc-MIBI scintimammography (SMM) in the detection of primary breast cancer and metastatic axillary lymph node involvement, and the scintigraphic results with the histopathological/cytological findings. **MATERIAL AND METHODS:** 303 consecutive patients with 308 suspicious or indeterminate lesions observed in mammographies were entered in this study. After an intravenous injection of 740 MBq of ^{99m}Tc-MIBI, anterior supine, right and left lateral planar images in a prone position and a SPECT study were acquired.

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RESULTS: 85 malignant and 223 benign breast lesions were confirmed by histopathology/cytology. The overall sensitivity in the detection of breast cancer was 92% (78/85) for SPECT and 82% (70/85) for planar imaging ($p = \text{NS}$), respectively; overall specificity was 91% (204/223) for SPECT and 91% (202/223) for planar scans ($p = \text{NS}$), respectively. Metastatic axillary lymph node involvement was seen in 35 patients; per-axilla overall sensitivity was 66% (23/35) for SPECT and 54% (19/35) for planar images (NS), respectively; overall specificity was 76% (38/50) and 86% (43/50), respectively (NS).

CONCLUSIONS: Our results confirm the high diagnostic accuracy of ^{99m}Tc-MIBI scintimammography in the diagnosis of breast cancer, and show SPECT to be slightly more sensitive than planar imaging, especially in detecting malignant breast lesions. We found the sensitivity of both imaging modalities to be quite low in the detection of metastatic axillary lymph node involvement. SPECT provides additional information to planar SMM with respect to the localization of ^{99m}Tc-MIBI uptake and tumour extent and improves diagnostic certainty. Our experience suggests that SPECT combined with planar SMM should be used more widely.

Keywords: ^{99m}Tc-MIBI, scintimammography, SPECT, breast cancer, axillary lymph node metastasis

Introduction

Breast cancer is the leading cause of cancer-related death in women throughout developed countries [1, 2]. Since patients with breast cancer detected at an early stage have a better survival rate [3], much work has been done to improve the early breast cancer detection.

Besides a physical examination, the most widely employed tool for the diagnosis of primary breast cancer is X-ray mammo-

graphy having a high value in visualizing breast lesions [4]. However, mammography can also yield false-negative results in some cases [5]; e.g., it is less reliable for detecting lesions in dense fibroglandular breasts [6]. In addition, it cannot always accurately differentiate between benign and malignant lesions [7–9] and it is characterized by a low specificity and a low positive predictive value [10]. Ultrasonography and magnetic resonance imaging can slightly improve the sensitivity of mammography in some conditions, a disadvantage of both being a low specificity [11–13].

^{99m}Tc-scintimammography (SMM) has been reported to have a high sensitivity as well as a high specificity for the depiction of breast carcinoma in selected populations [14–18]. These studies have been predominantly performed with high-resolution cameras using the planar imaging technique. There have been only a few reports on the use of SPECT breast imaging and the results as to its usefulness are still controversial [2, 11, 19–25]. The value of SPECT in SMM has yet to be fully established.

The aim of this study was to compare SPECT and planar ^{99m}Tc-MIBI imaging in the detection of primary breast cancer and axillary lymph node involvement, and to compare the scintigraphic results with the histopathological/cytological findings.

Materials and methods

Patients

Three hundred and three consecutive patients (300 females and 3 males) aged 17–82 years (mean 46 years) with 308 suspicious or indeterminate lesions on X-ray mammographies were entered in this study. All patients had previously undergone clinical examination, mammography and ultrasonography. One hundred seven lesions were palpable and 201 nonpalpable. Two hundred and fifty-three patients had the histopathologic confirmation by excisional or core needle biopsy, lumpectomy or mastectomy within 3 weeks following an SMM. In 55 patients, the fine-needle aspiration cytology results were used as the final diagnosis. In breast cancer patients, the final histopathological confirmation of axillary lymph node involvement was obtained after the lymph nodes excision at an axillary lymph node dissection (ALND).

^{99m}Tc-MIBI scintimammography protocol

The studies of all patients were performed using a dual-head gamma camera Apex Helix SPX (Elscint, Haifa, Israel) equipped with low-energy, high-resolution, parallel-hole collimators.

Planar imaging began 5–10 min after an IV injection of 740 MBq of ^{99m}Tc-MIBI in the arm contralateral to the breast with the suspicious abnormality or in a pedal vein. Radiolabelling and quality control procedures with respect to the tracer were carried out according to the manufacturers instructions. Images were obtained with a 256 × 256 matrix for the acquisition time of 10 min in both the lateral and anterior views. The lateral views were obtained in the prone position on special table with the breasts freely pendent while the anterior planar view was acquired in the supine position with the arms raised above the head and with the chest, both breasts and the axillae included in the field of view.

SPECT imaging was initiated at 20–30 min post-injection with a 64 × 64 matrix, a 180° rotation per head, a 3° angular step-and-shoot technique and the acquisition time of 30 s per frame. Filter Hanning, order 5, cut off 2.3 was applied for the reconstruction

with a filtered backprojection to produce transaxial slices. Coronal and saggital views were then obtained.

Data analysis

^{99m}Tc-MIBI uptake in planar and SPECT images of both breasts and axillae was visually evaluated separately. The scintigrams were classified as normal or abnormal. Focal tracer accumulation in the breast and the axilla was the criterion for a scan to be classified as abnormal.

The first-step analysis consisted of the separate evaluation of planar and SPECT imaging. The second-step analysis involved the interpretation of planar images combined with SPECT ones. The results of both diagnostic approaches — the separate (planar and SPECT) and the combined reading (planar plus SPECT) — were compared and correlated with the final histopathological/cytological diagnoses.

Statistical analysis

^{99m}Tc-MIBI planar and SPECT images were classified as true positive or false positive when images suggested malignancy and true negative or false negative when images did not reveal focal tracer uptake, considering histology/cytology as the “gold standard”. The sensitivity, specificity, positive and negative predictive value and accuracy of different approaches for the detection of both primary breast cancer and axillary lymph node metastasis were calculated. A statistical evaluation was performed using a χ^2 test. A p value < 0.05 was considered statistically significant.

Results

In 81 patients, 85 malignant lesions (nine histological types) were confirmed by histopathology (Table 1). Seventy-seven patients had unilateral disease while 4 had bilateral disease. Breast cancers (without 8 malignant lymphomas) were in the following pTNM stages: 2 carcinoma in situ, 39 pT1 (11 pT1b, 28 pT1c), 29 pT2, 4 pT3 and 4 pT4. The mean size of malignant lesions was 24 mm (range 6–52 mm) in greatest diameter. The smallest tumour was a mixed infiltrating ductal carcinoma and ductal carcinoma in situ (diameter 6 mm). The remaining patients had 223 benign lesions (Table 2).

Planar scintigraphy was able to locate correctly 70 of the malignant lesions while SPECT located 78. Planar imaging missed 15 malignant lesions while SPECT missed only seven.

Table 1. Histopathological findings (malignant breast lesions; n = 85)

Histology	Lesions (n)
Infiltrating ductal carcinoma	49
Infiltrating lobular carcinoma	13
Mixed ductal and lobular carcinoma	4
Mixed infiltrating ductal carcinoma and ductal carcinoma in situ	2
Ductal carcinoma in situ	2
Malignant lymphoma	8
Medullary carcinoma	5
Mucinous carcinoma	1
Papillary carcinoma	1
Total	85

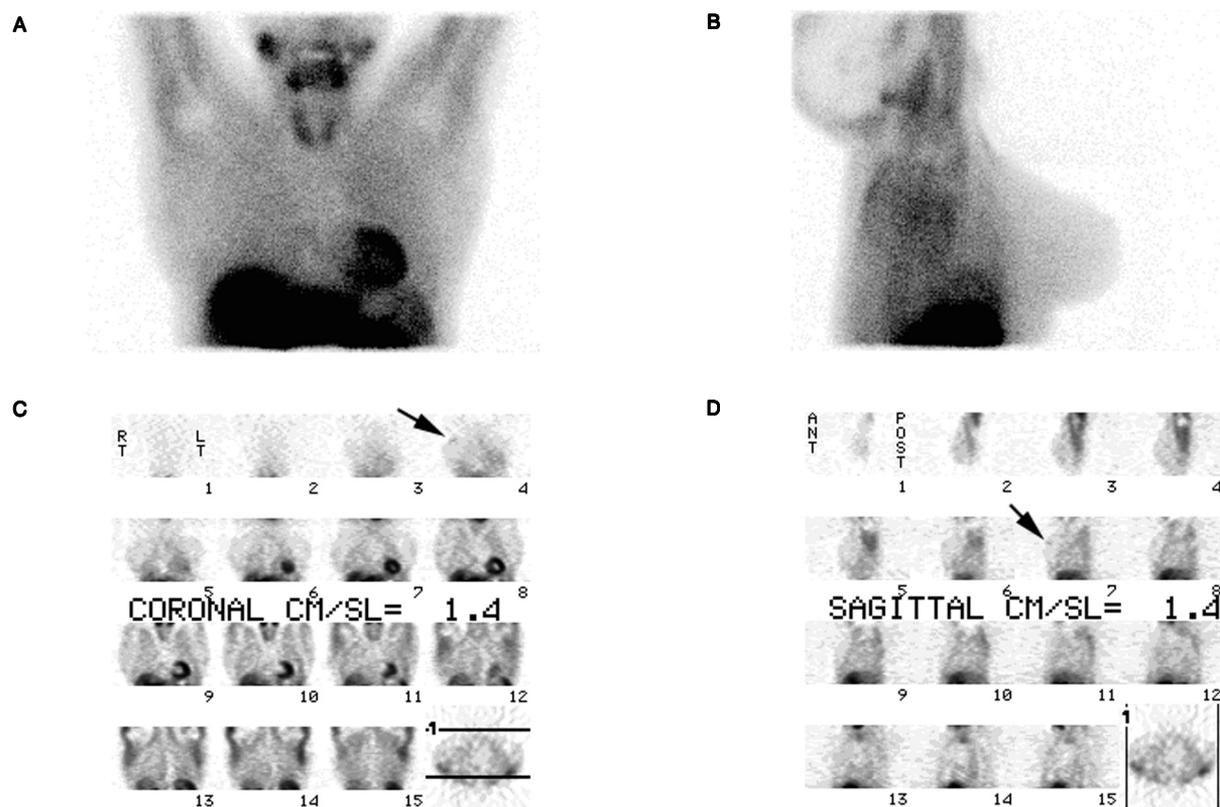


Figure 1. Patient with a proven non-palpable 11 mm infiltrating ductal carcinoma in the upper external quadrant of the right breast. Planar scintimammography does not show any site of abnormal ^{99m}Tc-MIBI uptake in both anterior (A) and right lateral prone (B) views. SPECT imaging shows a focal area of increased uptake corresponding to the carcinoma in both coronal (C) and sagittal (D) slices (arrows).

Table 2. Histopathological/cytological findings (benign conditions; n = 223)

Histology/cytology	Lesions (n)
Fibroadenoma	78
Fibrocystic disease	53
Intraductal papilloma	7
Atypical lobular hyperplasia	7
Ductal hyperplasia	4
Local inflammation	7
Florid adenosis	5
Dysplasia	7
Benign cytological finding	55
Total	223

Figure 1 shows a true-positive SPECT finding in a patient with non-palpable breast carcinoma that was negative on planar imaging. Twenty one benign lesions showed an uptake of ^{99m}Tc-MIBI on planar images while only 19 showed an uptake on SPECT. The overall sensitivity in the detection of malignant breast lesion was 82% for planar imaging and 92% for SPECT, and the overall specificity was 91% for both these modalities. The difference in sensitivity was not statistically significant (Table 3 and 4).

Tables 3 and 4 also summarize the results of the combined planar and SPECT interpretation. The overall sensitivity in the detection of malignant breast lesion was 92% and specificity 91%.

Table 3. Scintimammographic results (breast lesions; n = 308)

	Planar imaging	SPECT	Planar imaging + SPECT
True positive	70	78	78
True negative	202	204	202
False positive	21	19	21
False negative	15	7	7

Table 4. Statistical analysis of the results of planar and SPECT imaging and combined planar and SPECT evaluation (breast lesions; n = 308)

	Planar imaging	SPECT	p	Planar imaging + SPECT
Sensitivity	82% (70/85)	92% (78/85)	NS	92% (78/85)
Specificity	91% (202/223)	91% (204/223)	NS	91% (202/223)
PPV	77% (70/91)	80% (78/97)	NS	79% (78/99)
NPV	93% (202/217)	97% (204/211)	NS	97% (202/209)
Accuracy	88% (272/308)	92% (282/308)	NS	91% (280/308)

PPV — positive predictive value; NPV — negative predictive value; NS — non significant

Metastatic axillary lymph node involvement was seen in 35 patients: the results of the planar and SPECT imaging, and a combined interpretation of both modalities are summarized in

Table 5. Scintimammographic results (axillary lymph node involvement; n = 85)

	Planar imaging	SPECT	Planar imaging + + SPECT
True positive	19	23	23
True negative	43	38	36
False positive	7	12	14
False negative	16	12	12

Table 6. Statistical analysis of the results of planar and SPECT imaging and combined planar and SPECT imaging (axillary lymph node involvement; n = 85)

	Planar imaging	SPECT	p	Planar imaging + + SPECT
Sensitivity	54% (19/35)	66% (23/35)	NS	66% (23/35)
Specificity	89% (43/50)	76% (38/50)	NS	72% (36/50)
PPV	73% (19/26)	66% (23/35)	NS	62% (23/37)
NPV	73% (43/59)	76% (38/50)	NS	75% (36/48)
Accuracy	73% (62/85)	72% (61/85)	NS	69% (59/85)

PPV — positive predictive value; NPV — negative predictive value; NS — non significant

Tables 5 and 6. The overall sensitivity in the detection of axillary lymph node metastasis was 54% for planar imaging and 66% for SPECT; the overall specificity was 89% for planar imaging and 76% for SPECT. The differences were not statistically significant. For a combined interpretation of both planar and SPECT imaging, the overall sensitivity and specificity was 66% and 72%, respectively.

Discussion

We found SPECT to be somewhat more sensitive in detecting primary breast lesions than planar imaging (92% vs. 82%). However, the difference in sensitivity of both imaging modalities was not statistically significant.

Planar imaging missed 15 malignant lesions while SPECT failed to identify only seven. SPECT changed 8 false negative findings into true positive. The size of 8 undetected lesions by planar imaging ranged between 10 and 25 mm in greatest diameter. Planar imaging did not delineate any uptake of MIBI in 4 of these 8 cases with malignant lesions (2 infiltrating ductal carcinomas, 1 medullary carcinoma and 1 malignant lymphoma). In 3 patients with infiltrating ductal carcinoma, a diffuse uptake of MIBI was classified as a normal finding in planar imaging. In one patient, planar imaging was unable to detect a malignant lesion (infiltrating lobular carcinoma, 23 mm in size) which was localized close to the chest wall; the absence of the focal MIBI uptake was probably caused by the superimposition of background activity. Four of the 8 false positive images were localized in internal lower quadrants of the breast. All of these 8 patients had a clear focal uptake of MIBI on the SPECT images enabling its visualization in different slice orientations.

Twenty-one benign breast lesions showed the focal uptake of MIBI on planar imaging while only 19 showed the uptake on SPECT. However, specificity of SPECT was the same as that of planar SMM in detecting primary breast lesions; similar values in the specificity of SPECT and planar imaging have been reported by Palmedo et al [2] and Aziz et al [22], in contrast to other authors [11, 19–21, 23, 25].

Other studies compared planar and SPECT ^{99m}Tc-MIBI imaging for the detection of primary breast cancer with conflicting results. Some authors found that SPECT could not improve the diagnostic accuracy of planar scintimammography [2, 21] while data of others suggested that SPECT imaging was more sensitive [11, 19, 20, 22, 23, 25].

In agreement with some authors [2, 19, 24], we found SPECT to be useful in determining the extent of tumours and in localizing them precisely in some patients. As well as this, the interpretation of SPECT scans was easier in some cases in comparison to planar images alone. According to Tiling et al [19], SPECT was useful only in cases of indeterminate and positive planar scintimammography but if planar SMM was negative, the routine use of SPECT was questionable. In our study however, a relatively large number of lesions (8 of 85) would have been missed without performing SPECT imaging. Also, a study by Aziz et al [22] suggests that SPECT scintigraphy is useful in ruling out malignancy if there is no uptake seen in the breast on planar images. Spanu et al [11] recommend SPECT to be used more extensively in the management of breast cancer patients. Also, our experience supports the wider use of SPECT accompanied by planar SMM since the combination of both modalities has the potential to improve the detectability, particularly of tumours localized deep in the breast tissue and in internal quadrants of the breast.

Axillary lymph node metastases were detected in 19 of 35 patients using planar SMM and in 23 of 35 patients with SPECT (sensitivity 66% for SPECT and only 54% for planar imaging). False-positive interpretations occurred in 7 patients with planar SMM and in 12 patients using SPECT (specificity 86% for planar imaging and 76% for SPECT). The differences between the sensitivity and specificity of planar imaging and SPECT were not statistically significant. The results of a study by Schillaci et al [20, 26] show that SPECT is more sensitive than planar imaging especially in detecting axillary lymph node involvement. Spanu et al [11] found the per-axilla overall sensitivity of SPECT and planar imaging in the detection of axillary lymph node metastasis to be 93% and 52.3%, respectively. They proved that SPECT has a particularly important role in the detection of metastatic axillae with the involvement of ≤ 3 non-palpable lymph nodes. Although, in our study SPECT demonstrated a sometimes better resolution in areas of focal tracer accumulation, we found the sensitivity of both imaging modalities to be quite low in detecting axillary lymph node metastases.

In conclusion, our results show the sensitivity of SPECT to be slightly higher than that of planar imaging, especially in detecting malignant breast lesions. SPECT provides information additional to planar imaging as to the localization of the MIBI uptake and tumour extension and improves diagnostic certainty. On the basis of our experience up to now we recommend the wider use of SPECT combined with planar imaging.

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