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The role of dynamic imaging in sentinel lymph node biopsy in breast cancer

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Abstract

The aim of this study was to evaluate the role of dynamic imaging in sentinel lymph node (SLN) biopsy in breast cancer. Patients with T1/T2, N0 invasive breast cancer underwent SLN localisation using intra-dermal injection of 15 MBq of ^{99m}Tc-nanocolloid. Gamma camera anterior-oblique dynamic imaging commenced simultaneously with tracer administration for 45 min, and was followed by anterior and lateral static imaging. Dynamic imaging data was reformatted into image files of different time-frames. Patterns of uptake were analysed using the sequences of dynamic frames and time–activity curve (TAC). SLN localisation was successful in 70/73 studies (96%) in 72 patients. Imaging information was present within the first 15 min of dynamic imaging in 67/70 studies (96%). Critical analysis of dynamic data helped to differentiate true SLN from secondary echelon nodes in eight studies and transient foci of radioactivity in six studies. In 17 studies, SLN contained metastatic disease. The detection of SLN metastasis was independent from the use of dynamic imaging. Dynamic imaging improves the interpretation of preoperative SLN imaging for breast cancer, but does not contribute significantly to the successful detection of SLN. Hence, preoperative dynamic imaging is not necessary in SLN biopsy for breast cancer.

Keywords: Breast neoplasms; Neoplasm staging; Sentinel lymph node biopsy; Radionuclide imaging; Radioisotopes

1. Introduction

The sentinel lymph node (SLN) is the first lymph node(s) in the direct lymphatic drainage pathway of the primary tumour. Twenty series to date have shown that SLN can be localised over 90% of the time in patients with breast cancer and that SLN reliably predicts the axillary nodal status in 98% of all cases [1].

The combined intra-dermal delivery of radiopharmaceutical and blue dye to the skin overlying the tumour is gaining increasing popularity in SLN localisation for breast cancer because of its superior success rate [2]. The use of radiopharmaceutical enables preoperative visualisation of SLN. Although preoperative dynamic imaging has been demonstrated to be essential in SLN biopsy for malignant melanoma [3], there has been no published study to date in evaluating its role in SLN biopsy for breast cancer. The aim of this study was to evaluate the role of high resolution, early dynamic imaging in SLN biopsy for breast cancer, primarily through direct visualisation and analysis of radiopharmaceutical transit through lymphatic tracts.

2. Patients and methods

Patients with invasive breast cancer (<5 cm in size) and clinically axillary node-negative (T1/T2, N0) were recruited following informed consent. The study was approved by the local ethics committee and Administration of Radioactive Substances Advisory Committee (ARSAC). Each patient received a 0.2-ml intradermal injection of 15MBq ^{99m}Tc-nanocolloid (Nycomed Amersham, UK) to the skin overlying the palpable tumour or at the areolar border of the corresponding quadrant for impalpable tumour. The injection site was then massaged for 1 min.

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All data were acquired using a low energy high-resolution collimator (400XC/T Single-headed large field-of-view, GE Medical Systems, USA) with 140 keV, 20% width, 3% offset energy window, and 256×256 pixel matrix.

Anterior oblique (AO) dynamic imaging at 30° commenced immediately following injection for 45 min. The data were collected in a high resolution pixel matrix to allow for reformatting in later analysis. The data comprised 90×10-s frames, followed by 30×60-s frames. 5-min anterior and lateral static images with matched transmission images were acquired subsequent to the dynamic acquisition [4]. A 10-min static image was also acquired at 18–24 h post injection.

SLN biopsy was performed using gamma probe detection and intra-operative blue dye. Biopsy for internal mammary SLN was not performed. All patients had axillary lymph node dissection (ALND) unless refused by the patient. The number of SLN harvested was correlated to the number visualised on preoperative imaging.

The imaging data was stored and processed using the Star 3000 Computer System (GE Medical Systems, USA) and accompanying software (Genie Workstation). For each patient, data analysis was achieved by reformatting the raw dynamic dataset to generate the following additional image files:

i. 3×5-min frames (i.e. initial 15 min)
ii. 15×1-min frames (i.e. initial 15 min)
iii. 90×10-s frames (i.e. initial 15 min)
iv. 9×5-min frames (total 45 min)
v. 45×1-min frames (total 45 min)

Imaging data for each patient were interpreted blindly by an experienced observer. Early dynamic image data were assessed specifically for its value in identifying SLN(s) and interpreting patterns of uptake. This was carried out primarily through direct visualisation of the pattern of colloid transit through the lymphatic tracts. If visual interpretation of dynamic images remained inconclusive, time–activity curve (TAC) analysis was performed by plotting total counts within the radioactive hotspot versus time. Using the information gathered here, minimum requirements for the collection of early dynamic data were also determined.

3. Results

73 SLN localisations were performed. SLN imaging was successful in localising one or more SLN within the axilla in 68 of the 73 studies (93%). 2 patients had SLN in the internal mammary chain only. Rapid drainage of radiopharmaceutical was evident with axillary SLN clearly visible in 58 of 70 studies (83%) within the first 5 min of dynamic imaging and in 67 studies (96%) by 15 min.

Dynamic imaging demonstrated direct lymphatic tracks to SLN in 58 of 68 studies (85%) enabling the identification of the true SLN. These were only seen in the early dynamic images. The optimal dynamic imaging format is 1-min framing. 10-s frames each contained insufficient counts for image interpretation.

Critical analysis of dynamic data contributed to the interpretation in 14 studies (21%) by identifying seven secondary echelon nodes, six transient foci of colloidal uptake and one intra-mammary. In 12 studies, this was achieved by interpreting the sequence of dynamic frames alone. In two studies, TAC analysis was required to confirm the transient nature of uptake within the radioactive foci (Fig. 1).

The lateral static images assisted the detection of SLN during surgery by indicating the depth of the SLN beneath the anterior skin surface. Late static imaging did not provide additional information to early static imaging.

SLN biopsy was successful in 68 studies (100%) with axillary SLN, visualised preoperatively by imaging. ALND was performed in 65 studies. The number of SLN harvested in each case corresponded to the number of true SLN visualised by preoperative images. In 17 studies, SLN contained metastatic deposits, but in none of these cases was the detection of SLN metastasis dependent on dynamic imaging.

4. Discussion

The data in our study demonstrate that early dynamic imaging provides detailed information additional to that acquired by static imaging. This improved the interpretation of static images in 14/70 (20%) successful SLN localisations. Anterior-oblique dynamic imaging was superior to anterior static imaging. It is important to note that this applies to the intradermal injection technique with a single small-volume tracer depot. The latter allows image data of high technical quality to be obtained, and with the use of dynamic imaging, direct observation of the lymphatic tracts and visualisation of SLN sited in close proximity to the injection site are possible.

Our study demonstrated rapid flow of radiopharmaceutical and successful localisation of SLN within 15 min in 96% of cases following intradermal injection. Therefore, SLN localisation using intradermal injection of radiopharmaceutical can be performed on the day of SLN biopsy.

From our experience, 1-min frame formatting was the best for visual interpretation of dynamic imaging and for time activity analysis. The use of TAC is useful in determining the nature of hotspots if direct visualisation

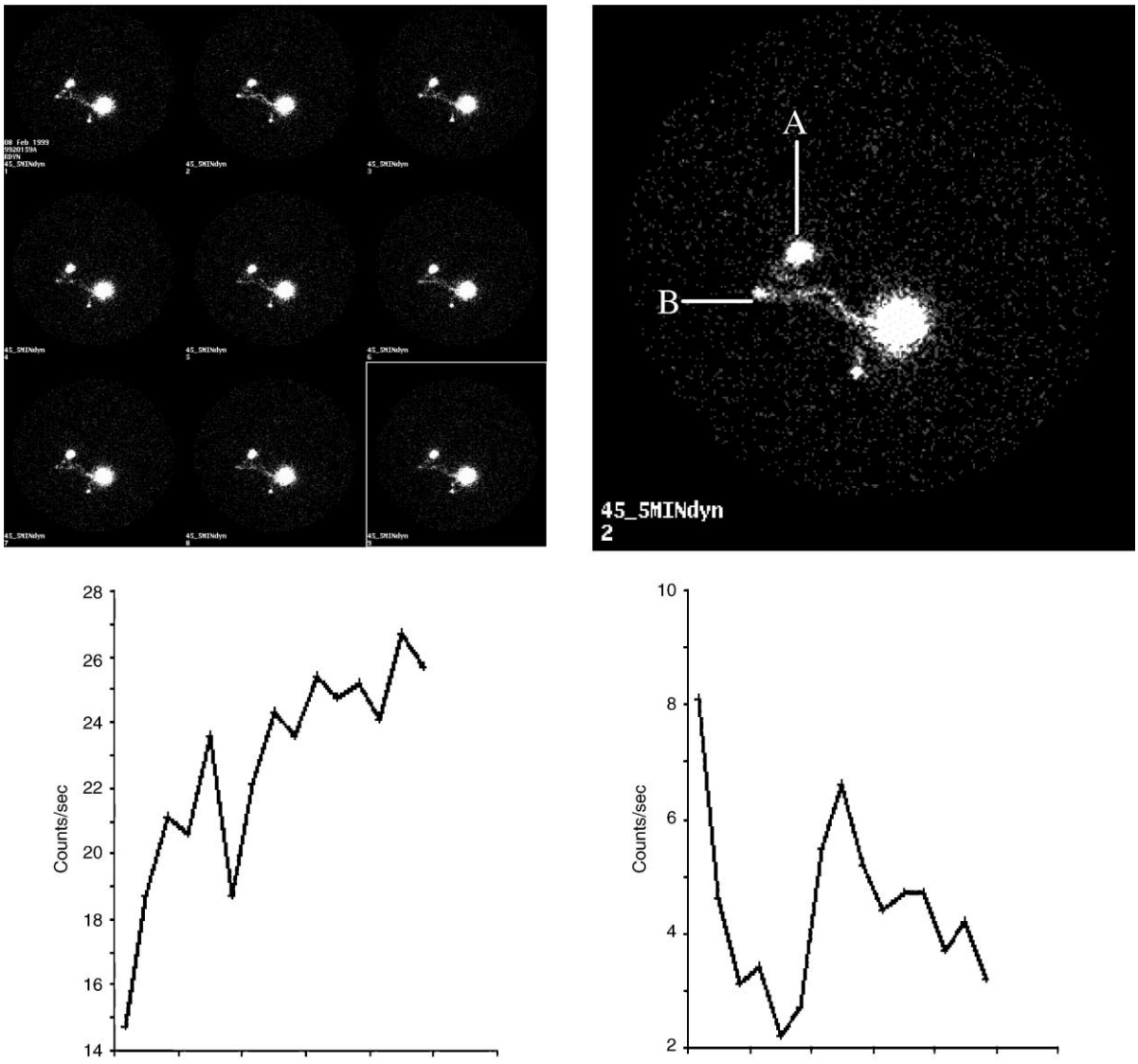

Fig. 1. Anterior-oblique dynamic image (top left) demonstrate two foci A and B in enlarged frame (top right) suggesting that B is a true SLN and A is a secondary echelon node. TAC of A (bottom left) shows increasing radioactivity over time confirming A as the SLN. TAC B (bottom right) shows decreasing radioactivity over time confirming B as a transient focus.

remains inconclusive. A steady rise of radioactivity is indicative of a lymph node, which accumulates radiopharmaceutical over time, whilst a progressive reduction of radioactivity implies a transient passage of radioactivity.

Late anterior static imaging does not provide additional information gained from early anterior static images, and is therefore not recommended. Lateral static imaging, however, offered useful anatomical information via its orthogonal projection and assistance in detection of the SLN at surgery.

Although dynamic imaging allows a better interpretation of preoperative SLN imaging, the successful detection of SLN metastasis in breast cancer was not dependent on dynamic imaging. Nevertheless, a single preoperative SLN scan informs the surgeon of the minimum number of SLN to be harvested. In contrast, using a gamma detecting probe alone forces the surgeon to survey the axilla 'blind'. Although some trials have demonstrated no significant advantage with imaging in SLN biopsy in breast cancer [5,6], Pijpers and colleagues reported that preoperative imaging can identified an additional 10% who may have failed to demonstrate a hot node at intra-operative probing [7]. A study of 1436 patients by Wong and colleagues showed that the false-negative rate of SLN biopsy for patients with a single SLN was 14.3% compared with 4.3% in patients with multiple SLN [8], which can be confirmed by preoperative imaging. SLN biopsy without preoperative imaging can be considered entirely operator dependent

without an independent mechanism to ensure complete procedure. However, meticulous technique in the intra-operative detection by the gamma probe remains essential.

5. Conclusions

Dynamic imaging improves the interpretation of SLN imaging in breast cancer. However, it does not offer additional clinical benefit and hence it is not necessary in SLN biopsy for breast cancer. With intradermal administration of the radiopharmaceutical, the SLN can be successfully visualised within 15 min.

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