The Usefulness of a Preoperative Compact Imager, a Hand-Held γ-Camera for Breast Cancer Sentinel Node Biopsy: Final Results of a Prospective Double-Blind, Clinical Study

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The aim of this study was to compare the effectiveness of a hand-held preoperative compact imager (POCI) camera with conventional lymphoscintigraphy using a γ-camera for sentinel lymph node (SLN) detection in breast cancer. **Methods:** The main objective was to demonstrate the noninferiority of the POCI relative to conventional lymphoscintigraphy and to compare the number of SLNs detected by the 2 imaging devices. Our study, a clinical prospective, double-blind, noninferiority study, planned to include 200 patients with early breast cancer and started in January 2006. A standard SLN protocol (4 periareolar injections of 37 MBq of ^{99m}Tc-nanocolloids, 2 h before lymphoscintigraphy) was performed preoperatively using a conventional γ-camera and then the POCI camera. Scans were obtained by 2 different nuclear medicine physicians unaware of each other's results. The day after, in the operating room, the surgeon, after receiving the previous results, used the counting probe for surgical SLN biopsy. The number and localization of axillary SLNs obtained by lymphoscintigraphy and the POCI and the duration of the whole procedure were determined. **Results:** Among the 162 patients included, 138 were evaluable. The POCI detected more SLNs than did lymphoscintigraphy in 50 patients (36%), the same number of in 54 patients (39%), and fewer SLNs in 34 patients (25%), representing 84 (61%) discordant pairs. The noninferiority of preoperative compact imaging of axillary SLNs numbers was found to be statistically significant (95% confidence interval, 30%–52%, $P = 0.025$) using the McNemar test. The duration of acquisition was shorter using the POCI (<10 min in 84% [$n = 117$] of patients; mean, 7.5 ± 3.3 min) than lymphoscintigraphy (13% [$n = 18$] of patients; mean, 15.7 ± 3.4 min), with $P < 0.001$ using the McNemar test for paired proportions. **Conclusion:** Preoperative compact imaging using a hand-held camera was able to predict the number and localization of breast cancer SLNs and was not inferior to conventional lymphoscintigraphy in this study. Further studies will determine whether preoperative compact imaging could replace lymphoscintigraphy, especially in surgical centers without an on-site nuclear medicine department.

Key Words: breast; instrumentation; lymphoscintigraphy; hand-held gamma camera; sentinel node

The disease status of the axillary lymph nodes (LNs) is the most significant prognostic factor for patients with early-stage breast cancer (BC) (*1*). Thus, reliance on histologic examination of the LNs remains the most accurate method for assessing spread of disease—important not only for staging and prognosis but also for treatment selection guiding (*1*). For many years, the use of sentinel lymph node (SLN) identification and a sampling procedure referred to as sentinel node biopsy (SNB) has progressively reduced the need for axillary lymph node dissection (*2*) and avoided its associated morbidity. This procedure has now become practiced worldwide (*3*).

Currently, dual detection of SLN with blue dye and radioactive colloids is considered the reference method (*4,5*). Dual detection not only improves the detection rate (estimated at ~95%) but also reduces the risk of false-negative results and of axillary relapse in the cases in which axillary dissection is not undertaken because the SLN is nonmetastatic. False-negative results are the main weakness of this technique, because they can potentially lead to undertreatment. When radiolabeling is used, international experts (*5*) recommend not only dual detection but also preoperative lymphoscintigraphy to predict the success of the procedure, establish a precise map of the hot SLN (axillary or extraaxillary), and determine the number of SLNs detected. Preoperative lymphoscintigraphy also aids the surgeon by showing the precise axillary location of the SLN (base of the axilla or higher). A recent series (*6*) of 1,201 patients showed that the visualization of axillary SLN procedure by preoperative lymphoscintigraphy was asso-

ciated with a higher detection rate (98.7% with vs. 93% without; $P < 0.001$). However, no randomized studies have so far compared the detection and false-negative rates with and without the use of preoperative lymphoscintigraphy.

Thus, many teams that are skeptical about the value of preoperative lymphoscintigraphy (7) believe this technique complicates the SLN procedure without providing any real benefit. This attitude is partly due to the scarcity in several countries of medical centers possessing nuclear medicine departments and to cost issues. The γ-cameras used for preoperative lymphoscintigraphy in the nuclear medicine departments are often in use for other medical examinations. Moreover, the examination takes about 15–35 min, during which the patient has to remain immobile. For teams without easy access to preoperative lymphoscintigraphy, options include limiting the procedure to patients most likely to benefit from it, using blue dye alone (not the optimal technique), or undertaking the procedure without preoperative scintigraphy, which is contrary to international recommendations.

In this context, many laboratories and companies have developed hand-held γ-cameras with different technologies (8–15). Some of them have been evaluated in different clinical applications such as parathyroid imaging (16–19), brain (20), bone tumors (21,22), and SNB procedures in BC (21,23–30) and more recently in melanoma and gynecologic cancers (31), head and neck cancers (32), and prostate (33) or other urologic cancers (34). Few prospective and masked clinical studies, however, have been conducted to ensure that these devices performed as well as conventional γ-cameras in clinical routine practice.

The aim of this present clinical trial was to evaluate the ability of hand-held γ-cameras to simplify preoperative lymphoscintigraphy and optimize patient throughput, particularly in hospitals that lack a nuclear medicine department. This clinical trial was performed with a hand-held γ-camera prototype called preoperative compact imager (POCI) developed by the Nuclear Physics Institute and the Imaging and Modeling in Neurobiology and Cancerology Laboratory (24).

We designed a prospective study to compare the performance of the POCI device with conventional preoperative lymphoscintigraphy using a γ-camera in patients with early BC requiring SNB after combined detection. The objective was to assess if preoperative compact imaging could replace classic preoperative lymphoscintigraphy, without affecting patient outcome. The POCI, if shown to be noninferior to conventional preoperative lymphoscintigraphy regarding the number of SLNs detected, could be used routinely to create a radioactive map of the axillary or extraaxillary areas. Moreover, the use of the POCI to perform lymphoscintigraphy could improve access to dual-detection SLN procedures.

MATERIALS AND METHODS

Materials

The POCI device was designed to be easy to handle and ensure accurate and real-time radioguided detection of tumors during surgery (Fig. 1). The simplicity of its clinical use is due to a pedal footswitch that can be pressed to start and stop the image acquisition. The POCI device combines compactness, lightness, and high performance with a 40-mm-diameter field of view. The imaging head comprises a high-resolution parallel-hole lead collimator coupled to a 3-mm-thick continuous CsI(Na) crystal plate. The power and electronic module is connected to the camera by a 5-m-long wire cable. Data and image processing are performed in real time by a personal computer.

The camera has an outer diameter of 9.5 cm, a thickness of 9 cm, and a weight of 1.2 kg.

The physical performance of the POCI device is well detailed in the article published by Pitre et al. (24). The spatial resolution is 2.3 mm in full width at half maximum at 140 keV, much smaller than that of γ-cameras used in nuclear medicine departments (~1 cm for SLN localization). The full-width-at-half-maximum energy resolution of the 140-keV full-energy peak is 28%. The sensitivity is 290 cps/MBq. An image of the SLN can be acquired in a few seconds using a total typical injected dose for lymphatic mapping of about 150 MBq, and 1% diffuses into 1 SLN. Associated to a surface of analysis of 13 cm^2, this good sensitivity allows investigation of the axilla or operative wound, without stretching the duration of surgical tumor ablation (24).

Patients

The patients were older than 18 y, had early BC confirmed by histopathology on core biopsy or cytopathology, a unifocal tumor no more than 20 mm in largest dimension as measured by mammography or ultrasound, and no clinically palpable axillary LN. All patients gave informed written consent to the SLN biopsy procedure and axillary LN detection using the POCI.

Exclusion criteria patients were an age younger than 18 y, multifocal BC, prior neoadjuvant chemotherapy, clinically palpable axillary LN, pregnancy, and a prior history of surgery of the axilla or breast plastic surgery.
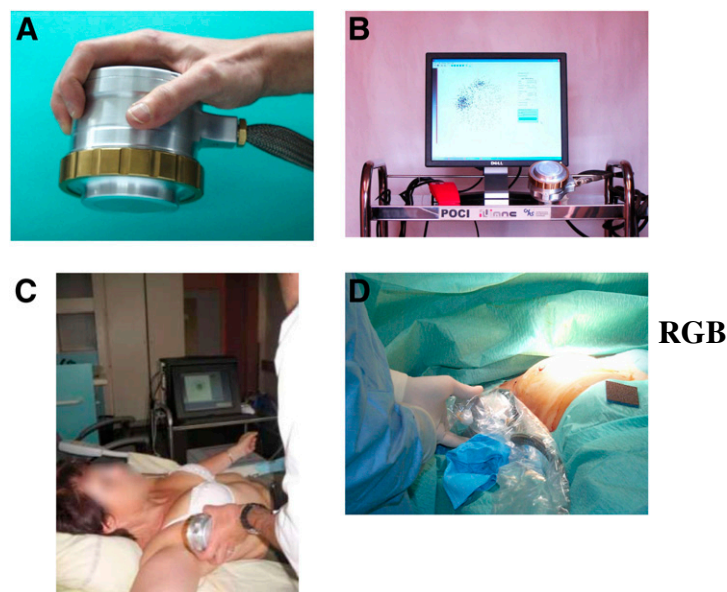

RGB

FIGURE 1. (A) Handheld POCI camera. (B) POCI device on its clinical trolley. (C) POCI device in patient room. (D) POCI device in operating room.
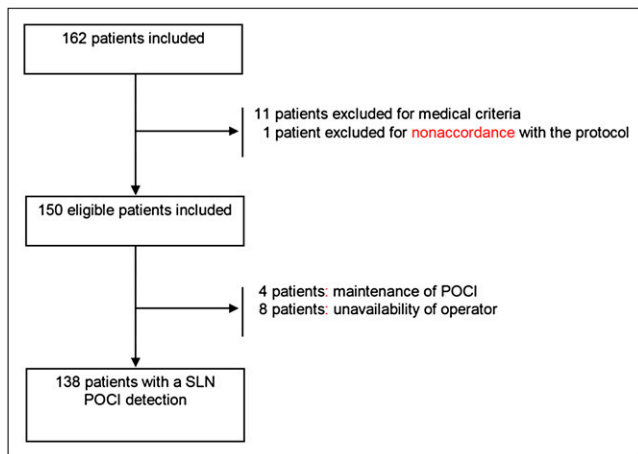
FIGURE 2. Flowchart of patients.

Sample Size

Because each patient was her own control in this study, a concordant pair was defined as identical numbers of radioactive SLNs detected by lymphoscintigraphy and preoperative compact imaging for the same patient. A discordant pair was defined as different numbers of radioactive SLNs detected by lymphoscintigraphy and preoperative compact imaging.

The number of patients to include was calculated according to the following considerations and hypotheses. It was postulated that in no more than 3% of patients (a clinically acceptable percentage) should preoperative compact imaging be shown inferior to lymphoscintigraphy. The expected number of discordant pairs was estimated to be around 10% and the noninferiority margin to be 30%, meaning that the difference of performance showing an inferiority of preoperative compact imaging relative to lymphoscintigraphy would have concerned only 30% × 10% = 3% of patients. However, because no previous publication or preliminary series had estimated the percentage of discordant pairs, it was decided to adjust the noninferiority margin accordingly with the obtained results, so as to not exceed the 3% determined as clinically acceptable.

According to these hypotheses, the minimal number of patients to be included was 171 with the hypothesis of 10% discordant pairs and 30% margin. The minimal number was calculated by the McNemar test applied to the noninferiority formula: $n = (1,645 + 0.84)^2/0.3^2 \times (0.5^2/10\%)$ (35).

Main Judgment Criteria

The performances of the POCI and lymphoscintigraphy were evaluated through direct comparison of the numbers of SLN obtained from both modalities on the same patient and the discordance of these results. For each patient, conventional lymphoscintigraphy and preoperative compact imaging detection were performed on the same preoperative day by 2 different nuclear medicine physicians, unaware of each other's results. The patients presenting discordance of the numbers of SLNs detected between the 2 methods were analyzed, and those showing fewer SLNs with preoperative compact imaging detection than with conventional lymphoscintigraphy were further computed.

SLN Protocol

The SLN protocol consists of four 0.2-mL periareolar injections, each containing 37 MBq of ^{99m}Tc-labeled nanocolloids (Nanocis; CIS Bio International), administered 2 h before lymphoscintigraphy

in the nuclear medicine department. Lymphoscintigraphy was performed by a standard triple-head γ-camera (IRIX Marconi; Philips) equipped with high-resolution low-energy collimators. Anterior and posterior simultaneous views, with a 256 × 256 matrix and 20% energy window centered on the 140-keV ^{99m}Tc photopeak, were acquired in 5 min. In the case of radioactive SLN visualization, a transmission image with uniform ^{57}Co source in the projection best showing SLNs was acquired in 5 min to provide anatomic landmarks for the surgeon. A second attempt was made 30 min later if no SLN was detected after the first acquisition.

Then, preoperative compact imaging was performed in the patient's room in the gynecology department between 5 min and 2 h after lymphoscintigraphy. The whole axillary area was scanned with the POCI in contact with the patient's skin, using at least 5- to 10-s acquisitions with a 256 × 256 matrix. The POCI device was moved to scan the whole axillary area, and a screening for extra-axillary SLNs was then performed, focusing on the homolateral internal mammary and the infra- and the supraclavicular areas.

Statistical Analysis

As recommended for paired samples, only patients with discordant SLN numbers between the 2 modalities were analyzed. The repartition of the different pairs was defined as n1 (the number of patients in whom the POCI identified fewer SLNs than did lymphoscintigraphy), n2 (the number of patients in whom the POCI and lymphoscintigraphy identified the same number of nodes), and n3 (the number of patients in whom the POCI was more successful than lymphoscintigraphy). The statistical McNemar test was adapted to noninferiority trials (36), taking into account the noninferiority margin in the calculation of the theoretic sample size required for the test. A judgment of noninferiority was made if the distribution between n1 and n3 was close to 50%/50%, which was determined according to the margin of noninferiority Δ.

$H_0 = $ POCI $<$ lymphoscintigraphy
$H_1 = $ POCI $>$ lymphoscintigraphy

$$z = \frac{n_1 - n_3 - n\Delta}{\sqrt{n_3 + n_1 - n\Delta^2}} . \quad (36)$$

RESULTS

Between January 2006 and February 2008, 162 consecutive patients were enrolled and registered in the database. The flowchart of patients is shown in Figure 2. Eleven patients were excluded a posteriori on the basis of the exclusion criteria: size of tumor superior to 20 mm (5 patients), clinically palpable axillary LN (2 patients), prior history of breast plastic surgery (2 patients), multifocal BC (1 patient), and benign tumor (1 patient). The protocol was not followed for 1 patient (1 exclusion).

Eight patients were ineligible because of the unavailability of the operator and 4 more because the POCI device was undergoing maintenance.

Because of the 12 exclusions and the 12 other noneligible patients, the results regarding the main judgment criteria are for 138 patients.

TABLE 1
Patient and Tumor Characteristics

Characteristic...	Patients with available data (n)	Result
For patients		
Age at diagnosis (y)	138	58 ± 12
Body mass index (kg/m^2)	130	25 ±5
Prior history of cancer (n)	137	13 (9.5)
Familial history of BC (n)	138	47 (34)
For tumors		
Final size of tumor on histology (mm)	138	14.3 (8.7)
Histology subtypes (n)	138	
Invasive ductal carcinoma		83 (60)
Invasive lobular carcinoma		19 (14)
Intra ductal carcinoma		25 (18)
Others		11 (8)
Scarff-Bloom-Richardson grade (n)	116	
I		54 (47)
II		50 (43)
III		12 (10)
High Ki67 (>30%) (n)	115	15 (13)
Positive progesterone receptors (>10%) (n)	117	83 (71)
Positive estrogens receptors (>10%) (n)	118	105 (89)
Cerb2 overexpression (n)	117	10 (8.5)
Type of surgery (n)		
Lumpectomy (before SNB)	138	126 (91)
Immediate mastectomy	138	12 (9)
Axillary LN dissection	138	14 (10)

Data in parentheses are percentages.

The clinical characteristics of the patients and tumors are given in Table 1. Patients' mean age was 58 y (SD = 12), with a mean body mass index of 25 (SD = 5). All tumors were unilateral and of T1 type. The mean size of the tumors measured in histology was 14.3 mm (SD = 8.7) in their greatest dimension. The histologic subtype was invasive ductal carcinoma for 83 patients (60%), intraductal carcinoma in situ for 25 patients (18%), invasive lobular carcinoma for 19 patients (14%), and other histologic BC subtype for 11 patients (8%). Twelve patients (9%) had immediate mastectomy.

Lymphoscintigraphy Versus Preoperative Compact Imaging

Results of lymphoscintigraphy, compared with preoperative compact imaging, are detailed in Tables 2–5.

Two hundred thirty-six axillary SLNs were identified by lymphoscintigraphy (mean, 1.7; range, 0–6 per patient). Twenty-nine (range, 1–3) extraaxillary SLNs were identi-

fied in 16 patients. After lymphoscintigraphy, the day before surgery, the POCI identified 256 axillary SLNs (mean, 1.9; range, 0–6 per patient). Fifteen (1–3) extraaxillary SLNs were identified in 10 patients. Considering that 291 (mean, 2.3; range, 0–6 per patient) radioactive axillary SLNs were removed from the 138 patients as reference, the preoperative sensitivity for axillary SLN detection was 81% (95% confidence interval [CI], 76.5%–85.5%) for lymphoscintigraphy and 88% (95% CI, 84%–92%) for preoperative compact imaging. No SLN was seen in 6 patients for lymphoscintigraphy and 7 patients for the POCI (3 cases in common); thus, the success rate was 96% (132/138) for lymphoscintigraphy and 95% (131/138) for the POCI.

For axillary SLN detection, the results for lymphoscintigraphy and the POCI matched in 39% of the patients (54/138) and were discordant for the remaining 61% of patients (84/138). Because of our postulation preoperative compact imaging should be inferior to lymphoscintigraphy in no

TABLE 2
SLN Identification

Node	Lymphoscintigraphy			POCI			Surgery		
	n	Mean	Range	n	Mean	Range	n	Mean	Range
Axillary	236	1.7	0–6	256	1.9	0–6	291	2.3	0–6
Extraaxillary	29	16 patients	1–3	15	10 patients	1–3	—	—	—
SN not identified	6			7			—	—	—

TABLE 3
Number of Patients with Axillary and Extraaxillary Nodes Identified by Classic Lymphoscintigraphy and POCI on Day Before Surgery

Node	POCI identified fewer LNs than did lymphoscintigraphy	POCI performed equally as well as lymphoscintigraphy	POCI identified more LNs than did lymphoscintigraphy	Total (n)
Axillary	34 (25)	54 (39)	50 (36)	138
Extraaxillary	14 (10)	120 (87)	4 (3)	138

Data in parentheses are percentages.

more than 3% of patients, the noninferiority margin was therefore adjusted to $\Delta = 5\%$, to respect the limit of $61\% \times 5\% = 3\%$ of patients limit.

In 50 patients (36%), the POCI identified more SLNs than did lymphoscintigraphy, representing 60% (95% CI, 49%–70%) of the discordant pairs. In 34 patients (25%), lymphoscintigraphy identified more SLNs than did the POCI, representing 40% (95% CI, 30%–52%) of the discordant pairs. Because the upper limit of the 95% CI (52%) was less than 55% (50% + Δ) with a P value less than 0.05, the noninferiority of preoperative compact imaging, compared with lymphoscintigraphy, was proven.

The durations of lymphoscintigraphy and preoperative compact imaging examinations were also compared. Lymphoscintigraphy lasted a mean of 15.7 min (SD = 3.3), whereas with the POCI the nodes screening lasted a mean of only 7.5 min (SD = 1.7) including the extraaxillary area screening. The SLN detection with lymphoscintigraphy lasted the minimal acquisition time of 10 min or less in 18 patients (13%), and the whole detection with the POCI, including extraaxillary SLNs, lasted less than 10 min in 117 patients (84%). The difference was statistically significant, with a P value of 0.001 (McNemar test for paired series).

DISCUSSION

Our study shows that the characteristics and performance of the POCI are adequate for BC SLNs detection. For 15 y, many research laboratories have built miniaturized imagers (8,10–13,15), with different designs and performances. Today,

the performances of these imagers have converged to optimize the detection efficiency, in order to reduce the duration of acquisition. To achieve that feature, some cameras are even supplied with pinhole collimators, which can create difficulty with interpreting images because of zoom effects inherent to focus depth (37). In our case, the POCI device is equipped with a high-sensitivity parallel-hole collimator that allows image acquisition in 5–10 s. Once familiar with the POCI camera, the operator can identify and scan the region of interest more rapidly because nonradioactive areas can be skipped.

From a design and conception point of view, 2 different types of imagers coexist: those with small fields of view (5-cm maximum in their larger dimension) and those with 10 cm or more on their longest side. The devices of the first group have the advantage of being compact and are therefore portable (with no arm), meaning that they can easily be used in nuclear medicine departments, operating rooms, and also the patient's room. Their small analysis areas require performing rigorous scanning of the region of interest. Imagers belonging to the second group allow a picture of the whole axilla to be taken in 1 shot. Nevertheless, the large dimensions of these imagers prevent their head from being in close contact with the axilla and the consequent better resolution and precise topographic localization, and their weight is often greater than 2 kg, complicating their use and handling and imposing the necessity of an articulated arm.

TABLE 4
Results for Discordant Pairs of Patients

Result	Axillary nodes	Extraaxillary nodes
No. of discordant pairs	84 (61)	18 (13)
Noninferiority margin Δ	5%	23%
POCI < lymphoscintigraphy*	34	14
%	40%	78%
95% CI	30%–52%	52%–94%

*No. of patients in whom POCI has identified fewer LNs than lymphoscintigraphy.

$P = 0.025$ (McNemar test) with $\Delta = 0.05$ for axillary vs. extraaxillary. Data in parentheses are percentages.

TABLE 5
Duration of Examinations

Parameter	Lymphoscintigraphy* (n = 129)	POCI (n = 138)	P
Mean whole procedure acquisition time ± SD	15.7 ± 3.3 min	7.5 ± 1.7	
No. of patients whose examination lasted 10 min or less	18 (13)	117 (84)	<0.001**

*Durations were discrete data: 10, 15, 20, 25, or 30 min.
**Comparison McNemar test of percentage for paired series.
Data in parentheses are percentages.

Since 1997, our team has preferred portability and chosen to develop POCI (*38*) to offer the better ergonomics to the operator.

The clinical trials reported to date in the literature about compact γ-cameras are scarce (*10,25,28,30,39,40*), and our trial (which started in January 2006) is one of the first and biggest studies so far. Until now, the similar studies have investigated the use of compact γ-cameras versus surgical counting probes and have provided only a proof of concept or a descriptive analysis of the preoperative detection. All of these studies have not supported their results with comparative prospective studies and statistical tests, except the Italian team (*30*), which used a Student *t* test in a prospective study but in unpaired groups of patients, comparing the surgical probe in one group and the surgical probe plus the imaging probe in the other group, in the operating room. All of these studies concluded that compact γ-cameras had the potential to perform lymphoscintigraphy and to replace the standard γ-cameras.

Our trial was the first, to our knowledge, comparing the performances of conventional lymphoscintigraphy using a γ-camera and preoperative compact imaging using a hand-hand γ-camera on a large number of patients ($n > 100$). A similar comparative study was reported in 2005 by Goto et al. (*40*), but it was performed on only 19 patients. Furthermore, our trial was the first to be conducted in a prospective and masked manner, comparing lymphoscintigraphy and preoperative compact imaging in the same 138 patients. Our aim was to give a quantitative answer about the potential of a compact imager to replace conventional γ-cameras. Therefore, we chose to conduct a noninferiority trial between lymphoscintigraphy and the POCI for localization and counting SLNs. Noninferiority trials as frequency tests for treatment validation are increasing in the literature. Our study shows that the 2 methods are not very different and that the difference in performance remains smaller than the usual clinically acceptable percentage of 5%. We have chosen to reduce this percentage to 3% to more stringently evaluate this new-generation portable detector, with the ulterior motive of its further use in clinical practice.

The noninferiority of the POCI camera, compared with the standard γ-camera, was clearly demonstrated in our study ($P = 0.025$; McNemar adapted paired test for noninferiority) and was achieved in the designed setting or preoperative screening on the day before surgery. One surprise in our study was that the number of discordant pairs reached 61%. Before the study, it was estimated to be around 10% and the noninferiority margin to be 30% to respect the condition that in no more than 3% of patients ($10\% \times 30\%$) should preoperative compact imaging be shown inferior to lymphoscintigraphy. As no prior publications or preliminary series had estimated the percentage of discordant pairs, we decided to adjust the noninferiority margin according to the obtained results in order to not exceed the 3% limit, possibly leading to a different and probably bigger sample size than previously known and thus potentially reducing the power of our study. But despite this theoretic reduction in power and larger than expected number of discordant pairs, the non-inferiority of the POCI, compared with lymphoscintigraphy, was achieved, with an inferiority limit of 3%—a percentage less than the usually clinically acceptable 5% margin.

Nuclear medicine physicians who used the POCI identified more SLNs than they did with lymphoscintigraphy in 50 of 138 patients (36%), and the opposite was seen in only 34 patients (25%). For example, as Figure 3 shows, 5 SLNs [**Fig. 3**] close to each other are clearly detected on the image from the POCI device, whereas classic lymphoscintigraphy showed only 1 SLN. The excellent spatial resolution of the POCI camera allowed a more precise counting of SLNs.

For extraaxillary SLN detection, the clinical results of the POCI were inferior to those of lymphoscintigraphy, and noninferiority was not found but was not a study endpoint. First, the POCI device has a small field of view (13 cm^2), which does not allow a 1-shot screening of extraaxillary areas. Lymphoscintigraphy, however, with the large-field-of-view γ-camera, allowed the detection of extraaxillary SLNs in the same acquisition as for axillary ones. Second, the time that nuclear medicine physicians spent screening the extraaxillary areas could have been shorter than for the axilla because the extraaxillary SLNs are not excised either for biopsy in our routine practice or for this study.

The additional advantage to performing lymphoscintigraphy with this device was that the examination was much shorter, even if a meticulous scan of the axilla and of the extraaxillary areas were to be performed. This shorter duration could be reasonably reduced even further by avoiding the screening for extraaxillary areas because the eventual detection of a SLN in these locations has no clinical impact in routine practice.

The general recommendations for BC require lymphoscintigraphy in the SLN biopsy procedure (*4,5*). This examination has some limitations because of the use of standard γ-cameras—the main limitation being the need for a nuclear medicine department—and because of the duration of the examination, which sometimes keeps the patient a couple of hours in the nuclear medicine department. In addition, the benefit of portable γ-cameras has been a matter of debate (*7*). The hope is that these new portable γ-cameras will replace the standard γ-cameras, consequently making the
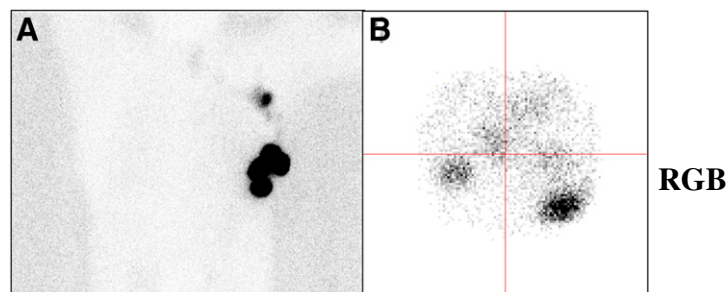

RGB

FIGURE 3. Lymphoscintigraphy in patient 73. (A) Lymphoscintigraphy performed with standard γ-camera, which identified 1 SLN. Image acquisition time was 5 min. (B) Lymphoscintigraphy performed by POCI device a few minutes later. Five SLNs were clearly identified. Image acquisition time was 79 s.

procedure easier and facilitating access to SLN biopsies for patients in hospitals lacking on-site nuclear medicine departments.

This study had some limitations. The higher than expected number of discordant pairs might have been a limitation and was already discussed. In addition, the fact that more than 90% of the POCI SLN detections were performed by the same operator could constitute a positive bias, because a learning curve, even if short, could exist for using this device. This situation might be different in real-life and with multioperator use, but like all the portable cameras, our POCI device is user-friendly and intuitively handled and controlled after 1 procedure.

Because preoperative compact imaging was always performed after conventional lymphoscintigraphy, more uptake might have migrated to additional SLNs at the time of preoperative compact imaging. The current study design may thus be biased into a higher number of SLNs detected by the POCI than with lymphoscintigraphy, therefore reducing the calculated inferiority of the POCI. To remove this bias, the order of imaging could have also been randomized.

Finally, these results were obtained in a single center; despite the prospective and masked design, this can be another limitation to the evaluation of the POCI performance. A multicenter prospective and masked phase III–like trial could definitively answer this question.

CONCLUSION

We have shown in a large-scale, prospective, and masked study that the POCI was able to predict the number and localization of BC axillary SLNs and was not inferior to conventional lymphoscintigraphy in a statistically significant manner.

These performances were also achievable for shorter acquisitions than are used for conventional lymphoscintigraphy. The POCI device is therefore a reliable tool to replace standard γ-cameras in clinical practice, especially in surgical centers without on-site nuclear medicine departments.

DISCLOSURE STATEMENT

ACKNOWLEDGMENTS

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