

^{99m}Tc -labeled sodium phytate and stannous chloride injection accurately detects sentinel lymph node in axillary of early stage breast cancer: a randomized, controlled study

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Aim: The aim of this study was to assess the sentinel lymph node (SLN) detection rate and accuracy of ^{99m}Tc -labeled sodium phytate and stannous chloride (^{99m}Tc -PHY) injection versus ^{99m}Tc -labeled sulfur colloid (^{99m}Tc -SC) injection in sentinel lymph node biopsy (SLNB) in patients with early stage breast cancer.

Methods: A total of 146 consecutive female patients with early stage breast cancer were recruited in this open-labeled, randomized, controlled study. SLNB was conducted on all patients, and ^{99m}Tc -PHY or ^{99m}Tc -SC was used as the radioactive agent (RA). Axillary lymph node dissections were performed in all patients post SLN dissections.

Results: The detection rate of ^{99m}Tc -PHY group was higher compared with that of ^{99m}Tc -SC group ($p=0.023$), but no difference in the detection rate by dye alone ($p=0.190$) or by RAs alone ($p=0.615$) was found between the two groups, and the number of identified SLNs ($p=0.100$), number of identified SLNs by dye alone ($p=0.161$), and number of identified SLNs by RA alone ($p=0.242$) were similar between the two groups. In addition, the sensitivity, specificity, false-negative rate, false-positive rate, and accuracy rate of SLNB showed no difference between ^{99m}Tc -PHY and ^{99m}Tc -SC groups (sensitivity: $p=0.645$; specificity: $p=0.511$; false-negative rate: $p=0.645$; false-positive rate: $p=0.511$; accuracy rate: $p=0.464$).

Conclusion: Our study revealed that ^{99m}Tc -PHY was qualified to be a convincing radiopharmaceutical in SLNB.

Keywords: breast cancer, sentinel lymph node biopsy, ^{99m}Tc , sodium phytate, stannous chloride, detection rate

Introduction

Breast cancer, the most frequent cancer among females, shows escalations of both incidence and mortality in Asia, South America, and Africa while a decline in Europe due to advanced screening programs in general population.^{1,2} Compared with other cancers, breast cancer is characterized by hormone-related and human epidermal growth factor receptor-2-related features in its pathogenesis.^{3,4} Treatment procedures for breast cancer include systemic therapy and resections, among which breast preservation becomes a preferred approach in order to improve the quality of life.⁵

Axillary lymph node dissection (ALND) has become a routine and a standard procedure in the management of breast cancer patients and a method for lymph metastasis staging over decades.⁶ Until now, ALND combined with histopathological examination is still a gold standard for assessing the axillary lymph node involvement.⁷ Nevertheless,

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patients who received ALND have high morbidity rate, and the acute complication rate could reach 20%–30%.⁸ The axillary lymph node metastasis is the integral risk factor of poor prognosis in breast cancer patients; however, the high morbidity and ALND caused complications, including edema, pain, and physical inactivity of the infected side, which largely limit the practicability of ALND in clinical practice, leading to the existence of sentinel lymph node biopsy (SLNB), which has become the standard process for assessing axillary lymphatic metastasis in early stage breast cancer.^{1,9,10}

SLNB is a minimally invasive surgery that detects the axillary lymphatic metastasis by sequentially locating and performing histopathological biopsy on sentinel lymph node (SLN).¹¹ In previous studies, SLNB presented a relatively low false-negative rate of 5%–10% as well as a high sensitivity of 90%–95%, indicating that SLNB is a procedure of high accuracy and might be an optimal option for reducing unnecessary ALNDs.^{12,13} Location of SLN is normally assessed by injecting blue dye or radioisotope technetium-labeled nano colloid, which could also be other isotopic carriers such as rituximab and dextran.^{14–16} Despite that sulfur colloid (SC) or albumin colloid is the most common radiotracer, the detection rate, true-positive rate, and false-negative rate varied among studies and were not satisfactory, thus, no standard or optimal carriers were identified in SLN location.^{17,18} Sodium phytate and stannous chloride (PHY) has been used in lymphoscintigraphies for liver, spleen, and bone marrow, and it has been reported that PHY could be used as radiotracer in SLNB for patients with papillary thyroid carcinoma.^{19,20} However, PHY has not been studied and used as an isotopic carrier for localization of SLN in breast cancer.

Therefore, the aim of this study was to assess the SLN detection rate and accuracy of ^{99m}Tc-labeled sodium phytate and stannous chloride (^{99m}Tc-PHY) injection versus ^{99m}Tc-labeled sulfur colloid (^{99m}Tc-SC) injection in patients with early stage breast cancer.

Methods

Participants

A total of 146 consecutive female patients with breast cancer from February 2012 to December 2015 at the Department of Breast Surgery in Gansu Provincial Cancer Hospital were recruited in this open-labeled, randomized, controlled study. The inclusion criteria were as follows: 1) age >18 years; 2) diagnosed of breast cancer based on clinical manifestations and radiological and histological findings; 3) clinical stage at T_{is}–T₃; 4) clinically negative lymph node metastasis; 5) diagnosed as eligible for resections; and 6) no preoperative clinical

or radiologic evidence for metastases. Patients with the following features were excluded: 1) previous major surgery on breast or axillary with lymph backflow destruction; 2) multicenter or multifocal breast cancer; 3) confirmed axillary lymph node metastasis; 4) previous treatments of radiotherapy, chemotherapy, or targeted therapy; 5) pregnant or lactating patients; and 6) cognitive impairment or poor adherence and could not understand the study protocol. This study was approved by the ethics committee of Gansu Provincial Cancer Hospital and conducted in accordance with the Declaration of Helsinki. All the participants provided signed informed consents.

Study design and randomization

This research was an open-labeled, noninferior, randomized, controlled study. The calculated minimum size sample was 63 for each group (126 totally) according to noninferiority trial balanced design (in this study, 146 participants were enrolled; the sample size was >126). All patients were randomized in 1:1 ratio to ^{99m}Tc-PHY and ^{99m}Tc-SC groups, using a block randomization method by SAS software. The randomization was conducted by a separate statistical analyzer, and the documents were sent and kept in Shanghai Qeejen bio-tech Company (a medical and statistic service company). When a patient was eligible for the study, a call was made to Qeejen Company and a unique subject identification number was provided from the randomized module.

Equipment and materials

In this study, the Neoprobe 2000 γ probe detector (Johnson & Johnson, New Brunswick, NJ, USA) was used for identifying SLN. Single-photon emission computed tomography (SPECT) was achieved by dual-head Discovery VH SPECT scanner (GE Healthcare, Pittsburgh, PA, USA). Esaote MyLab Twice Color Doppler Ultrasonic Diagnosis Apparatus (Esaote, Florence, Italy) was used for locating the SLN and performing aspiration cytology. ^{99m}Tc was provided by Beijing Atom Hi-Tech Co., Ltd. (Beijing, China), and Liquid-based Thin-layer Cell Test Machine was provided by Hologic (Marlborough, MA, USA). Leica cm-1950 cryostat microtome was purchased from Leica Microsystems (Wetzlar, Germany). PHY for injection was obtained from Jiangsu Atom Medicine Research Institute Jiangyuan Pharmaceutical Factory (Jiangsu, China). The methylene blue was provided by Jumpcan Pharmaceutical Group Co., Ltd. (Jiangsu, China), and ultrasound contrast agent Sonovue was provided by Bracco Co., Ltd. (Milan, Italy).

Procedures

Before surgeries, the ultrasound contrast and aspiration biopsy were performed prior to lymphoscintigraphy on patients to

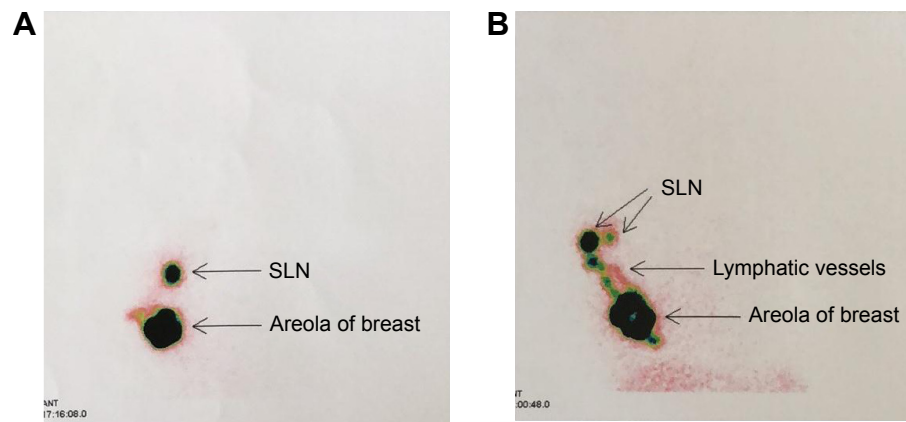


Figure 1 The lymphoscintigraphies in ^{99m}Tc -PHY and ^{99m}Tc -SC groups.

Notes: (A) The lymphoscintigraphy after RA injection, 1 hour before surgery in ^{99m}Tc -PHY group. (B) The lymphoscintigraphy after RA injection, 1 hour before surgery in ^{99m}Tc -SC group.

Abbreviations: ^{99m}Tc -PHY, ^{99m}Tc -labeled sodium phytate and stannous chloride; ^{99m}Tc -SC, ^{99m}Tc -labeled sulfur colloid; RA, radioactive agent; SLN, sentinel lymph node.

rule out some of the patients with SLN metastasis but was diagnosed as SLN metastasis negative in clinical practice before enrollment of our study for the purpose of lowering the false-negative rate. Three to eight hours prior to surgery, ^{99m}Tc -PHY (0.5 mL) or ^{99m}Tc -SC (0.5 mL) was injected into single site under the mammary areola subcutaneously, and the radiation intensity was 0.4–3.2 mCi. Lymphoscintigraphy was performed on the affected side and same-side axilla of each patient at 30–120 minutes after the injection. The examples of lymphoscintigraphies in ^{99m}Tc -PHY and ^{99m}Tc -SC groups were presented in Figure 1A and B, which were obtained 1 hour after RA injection. Meanwhile, methylene blue was subcutaneously injected 10–15 minutes before the surgeries; the injection sites included four peritumoral sites and one subareolar site. In addition, the blue dye was injected at different time points because blue dye has distinct flow velocity in lymphatic vessel compared to radiotracers and was injected at different sites because after the radiotracer injection there

might be inflammatory responses that could cause edema that blocks the lymphatic vessels. All the blue-stained and intensively radioactive SLNs were detected by the handheld γ probe detector, which were identified as the lymph node with the highest radioactivity count rate and lymph nodes with radioactivity count rate more than 10% of the highest radioactivity count rate (Figure 2A), and the radiation count rate of the SLN in Figure 2A was 805 (Figure 2B).^{21,22} The imprint cytology, intraoperative frozen section, and postoperative histopathological examination were carried out on dissected SLNs immediately. After SLN dissections, ALNDs were performed in all patients. The SLNB procedure was performed according to standard protocols described elsewhere.^{23,24}

Primary and secondary endpoints

The primary endpoint was the detection rate of SLN in each group. The secondary endpoints were as follows: detection rate of SLN by dye alone; detection rate of SLN

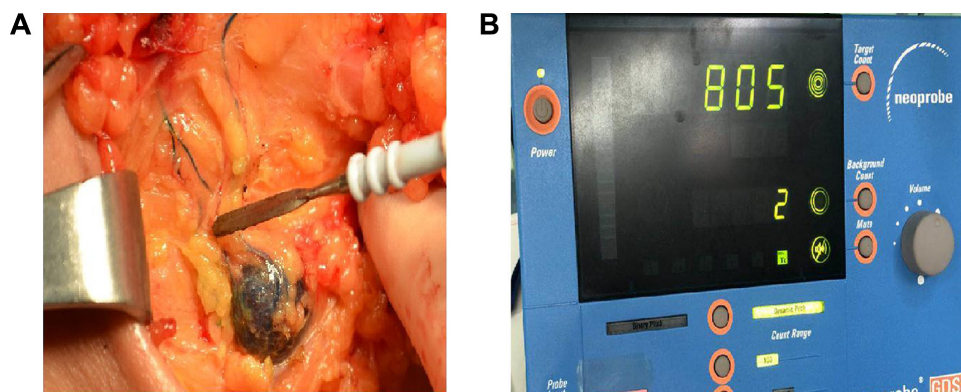


Figure 2 An identified SLN and its radiation count rate.

Notes: (A) An identified SLN. (B) The radiation count rate of the identified SLN.

Abbreviation: SLN, sentinel lymph node.

by radioactive agent (RA) alone; number of identified SLNs; sensitivity, specificity, false-negative rate, false-positive rate, and accuracy rate of SLNB.

Evaluation criteria

Sensitivity, specificity, false-negative rate, false-positive rate, and accuracy rate of SLNB were calculated according to criteria of SLNB by Louisville University as follows:²⁵ Sensitivity (%) = SLN true-positive cases/(SLN true-positive cases + SLN false-negative cases) * 100%; specificity (%) = SLN true-negative cases/(SLN true-negative cases + SLN false-positive cases) * 100%; false-negative rate (%) = SLN false-negative cases (SLN true-positive cases + SLN false-negative cases) * 100%; false-positive rate = SLN false-positive cases/(SLN true-negative cases + SLN false-positive cases) * 100%; accuracy rate = (SLN true-positive cases + SLN true-negative cases)/(SLN true-positive cases + SLN false-positive cases + SLN true-negative cases) * 100%; detection rate = cases detected with SLN/all cases.

Statistical analysis

Statistical analysis was performed using the SPSS 21.0 software. Data were mainly presented as mean \pm standard deviation (SD) and count (percentage). Difference between two groups was compared by *t*-test or chi-squared test. A *p*-value <0.05 was considered significant.

Results

Characteristics

As presented in Figure 3, 208 participants were screened for eligibility, among which 62 cases were excluded (29 for exclusion criterion, 26 for disagreement with informed consent, and 7 for other reasons). The remaining 146 participants were randomly allocated to ^{99m}Tc-PHY group (n=73) and ^{99m}Tc-SC group (n=73) in 1:1 ratio, and there was no withdrawal during the study for any reasons, thus finally 73 patients in ^{99m}Tc-PHY group and 73 patients in ^{99m}Tc-SC group were included in this analysis.

The 73 patients in ^{99m}Tc-PHY group had a mean age of 46.5 \pm 10.2 years, among which 35 cases (48%) had left breast cancer and 38 cases (52%) had right breast cancer, whereas patients in ^{99m}Tc-SC group had a mean age of 48.3 \pm 10.8 years, with 39 left breast cancer cases (53%) and 34 right breast cancer cases (47%). No difference in age, body mass index, side of breast cancer, menstrual status, primary tumor location, histopathologic type, and clinical T stage was found between ^{99m}Tc-PHY and ^{99m}Tc-SC groups as shown in Table 1.

Primary endpoint

SLNs were detected in all 73 patients in ^{99m}Tc-PHY group with the detection rate of 100%, which was higher than ^{99m}Tc-SC group with 68 out of 73 patients being detected with a detection rate of 93.2%, *p*=0.023 (Table 2).

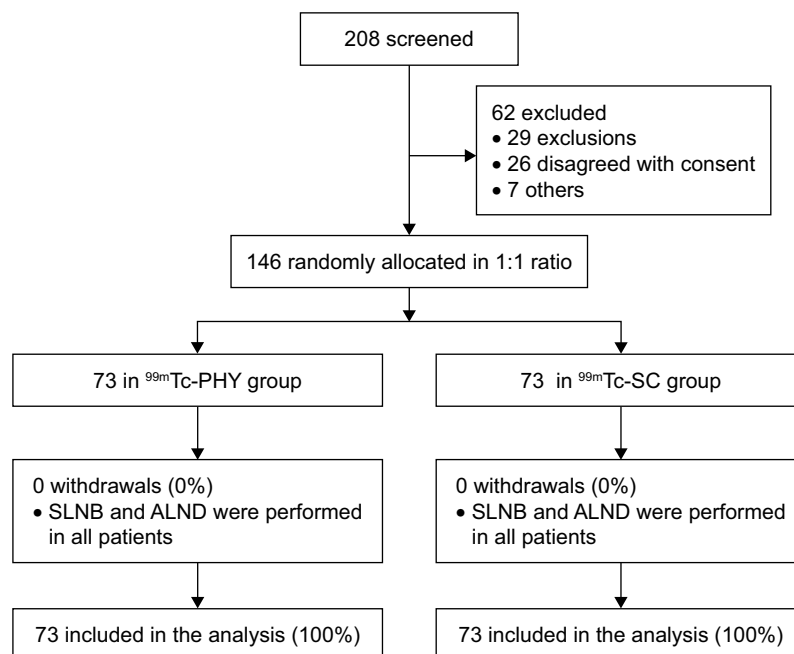


Figure 3 Study flow.

Note: 208 patients with breast cancer were screened for eligibility, and 62 were excluded, remaining 146 patients were randomly allocated in 1:1 ratio to ^{99m}Tc-PHY and ^{99m}Tc-SC groups.

Abbreviations: ^{99m}Tc-PHY, ^{99m}Tc-labeled sodium phytate and stannous chloride; ^{99m}Tc-SC, ^{99m}Tc-labeled sulfur colloid; SLNB, sentinel lymph node biopsy; ALND, axillary lymph node dissection.

Table 1 Demographic, clinical, and pathological characteristics of patients with breast cancer

Parameters	^{99m} Tc-PHY group	^{99m} Tc-SC group	p-value
Number of cases	73	73	–
Age (years)	46.5±10.2	48.3±10.8	0.302
Female	73 (100%)	73 (100%)	–
Body mass index (kg/m ²)	21.4±6.6	21.9±6.8	0.653
Side of breast cancer			0.508
Left	35 (48%)	39 (53%)	
Right	38 (52%)	34 (47%)	
Menstrual status			0.503
Menopausal	29 (40%)	33 (45%)	
Premenopausal	44 (60%)	40 (55%)	
Primary tumor location			0.816
Upper inner quadrant	4 (5%)	6 (8%)	
Lower inner quadrant	3 (4%)	2 (3%)	
Upper outer quadrant	49 (67%)	52 (71%)	
Lower outer quadrant	10 (14%)	9 (12%)	
Central portion	7 (10%)	4 (6%)	
Histopathologic type			0.166
Invasive ductal carcinoma	58 (80%)	63 (86%)	
Invasive lobular carcinoma	3 (4%)	5 (7%)	
Others	12 (16%)	5 (7%)	
Clinical T stage			0.365
T _{is}	2 (3%)	0 (0%)	
T ₁	19 (26%)	25 (34%)	
T ₂	45 (61%)	40 (55%)	
T ₃	7 (10%)	8 (11%)	

Notes: Data were presented as mean ± SD or counts (%). Significance of the comparison was determined by Student's *t*-test or chi-squared test. A *p*-value <0.05 was considered significant.

Abbreviations: ^{99m}Tc-PHY, ^{99m}Tc-labeled sodium phytate and stannous chloride; ^{99m}Tc-SC, ^{99m}Tc-labeled sulfur colloid.

Secondary endpoints

As listed in Table 2, SLNs were identified by dye in 70 patients (95.9%) in ^{99m}Tc-PHY group compared with 66 patients (90.4%) in ^{99m}Tc-SC group, no difference between the two groups was observed (*p*=0.190). Consistently, no difference in detection rate by RA was found between ^{99m}Tc-PHY and ^{99m}Tc-SC groups either (89.0% vs 86.3%, *p*=0.615).

Table 2 Detection rate of SLN in ^{99m}Tc-PHY and ^{99m}Tc-SC groups

Parameters	^{99m} Tc-PHY group	^{99m} Tc-SC group	p-value
Detection rate (n, %)	73 (100)	68 (93.2)	0.023
Detection rate by dye (n, %)	70 (95.9)	66 (90.4)	0.190
Detection rate by RA (n, %)	65 (89.0)	63 (86.3)	0.615
Number of identified SLNs	2.30±1.05	2.01±1.05	0.100
Number of identified SLNs by dye	2.23±1.14	1.97±1.09	0.161
Number of identified SLNs by RA	2.15±1.24	1.92±1.15	0.242

Notes: Data were presented as mean ± SD or counts (%). Significance of the comparison was determined by Student's *t*-test or chi-squared test. A *p*-value <0.05 was considered significant.

Abbreviations: RA, radioactive agent; SLN, sentinel lymph node; ^{99m}Tc-PHY, ^{99m}Tc-labeled sodium phytate and stannous chloride; ^{99m}Tc-SC, ^{99m}Tc-labeled sulfur colloid.

In ^{99m}Tc-PHY group, one SLN was detected in 16 patients (22%), two SLNs in 30 patients (41%), three SLNs in 20 patients (27%), four SLNs in four patients (5%), five SLNs in two patients (3%), and six SLNs in one patient (1%). While in ^{99m}Tc-SC group, 0 SLN was detected in five patients (7%), one SLN in 17 patients (23%), two SLNs in 30 patients (41%), three SLNs in 14 patients (19%), and four SLNs in seven patients (10%). The number of identified SLNs was similar between the two groups (2.30±1.05 vs 2.01±1.05, *p*=0.100) (Table 2), and as to number of identified SLNs by dye or RA, the results were the same (2.23±1.14 vs 1.97±1.09, *p*=0.161; 2.15±1.24 vs 1.92±1.15, *p*=0.242). In addition, the detection rates by RA and by dye were of no difference both in ^{99m}Tc-PHY group (*p*=0.117) and ^{99m}Tc-SC group (*p*=0.439).

In ^{99m}Tc-PHY group, SLNB illustrated that 18 cases were lymph node positive, among which 17 cases were true-positive cases and one was a false-positive case according to ALND results. The false-positive case was a patient without lymph node metastasis confirmed by the pathological examination from ALND but was diagnosed as lymph node metastasis positive according to the biopsy from SLNB. Meanwhile, SLNB showed that 55 cases were lymph node negative, among which 51 cases were true-negative cases and four were false-negative cases (*p*<0.001) (Table 3).

In ^{99m}Tc-SC group, SLNB disclosed that 17 cases were lymph node positive, among which 15 cases were true-positive cases and two were false-positive cases according to ALND results. Meanwhile, SLNB presented that 51 cases were lymph node negative, among which 46 cases were true-negative cases and five were false-negative cases (*p*<0.001) (Table 4).

The sensitivity, specificity, false-negative rate, false-positive rate, and accuracy rate of SLNB showed no difference between ^{99m}Tc-PHY and ^{99m}Tc-SC groups as presented in Table 5 (sensitivity: 81.0% vs 75.0%, *p*=0.645; specificity: 98.1% vs 95.8%, *p*=0.511; false-negative rate: 19.0% vs 25.0%, *p*=0.645; false-positive rate: 1.9% vs 4.2%, *p*=0.511; accuracy rate: 93.2% vs 89.7%, *p*=0.464, respectively).

Table 3 Pathologic comparison between SLNB status and ALND status in ^{99m}Tc-PHY group

^{99m} Tc-PHY group (n=73)				
Parameters	ALND positive	ALND negative	Total	p-value
SLNB positive	17	1	18	
SLNB negative	4	51	55	<0.001
Total	21	52		

Abbreviations: SLNB, sentinel lymph node biopsy; ALND, axillary lymph node dissection; ^{99m}Tc-PHY, ^{99m}Tc-labeled sodium phytate and stannous chloride.

Table 4 Pathologic comparison between SLNB status and ALND status in ^{99m}Tc -SC group

^{99m}Tc -SC group (n=68)				
Parameters	ALND positive	ALND negative	Total	p-value
SLNB positive	15	2	17	<0.001
SLNB negative	5	46	51	
Total	20	48		

Abbreviations: SLNB, sentinel lymph node biopsy; ALND, axillary lymph node dissection; ^{99m}Tc -SC, ^{99m}Tc -labeled sulfur colloid.

Safety

During and within 24 hours postoperation, no side effect was observed in either ^{99m}Tc -PHY group or ^{99m}Tc -SC group of this study.

Discussion

In the present study, the results elucidated that 1) the detection rate in ^{99m}Tc -PHY group was elevated compared with ^{99m}Tc -SC group; 2) no difference of identified SLN numbers was discovered between the two groups; 3) similar sensitivity, specificity, false-negative rate, false-positive rate, and accuracy rate of SLNB between the two groups were observed.

Females diagnosed with breast cancer, in all likelihood, will receive radical resections.¹ Fortunately, the advance of imaging techniques has led to an increasing possibility of small primary tumors to be discovered, which makes less invasive procedures and organ saving possible among patients.^{26–28} Thus, the ALND, which is one of the standard surgeries and resulted in several complications like lymphedema, should be avoided once verified unnecessary. SLNB, strikingly reduced the unnecessary ALNDs, has been developed regarding its efficacy and safety over years. In addition, for primary breast cancer patients, the adjuvant systemic therapy is determined by the lymph node metastasis condition, which could be detected by the SLNB.²⁹

Table 5 Sensitivity, specificity, false-negative rate, false-positive rate, and accuracy rate of SLNB

Parameters	^{99m}Tc -PHY group	^{99m}Tc -SC group	p-value
Sensitivity	81.0	75.0	0.645
Specificity	98.1	95.8	0.511
False-negative rate	19.0	25.0	0.645
False-positive rate	1.9	4.2	0.511
Accuracy rate	93.2	89.7	0.464

Notes: Data are presented as percentage. Significance of the comparison was determined by chi-squared test. A p-value <0.05 was considered significant.

Abbreviations: SLNB, sentinel lymph node biopsy; ^{99m}Tc -PHY, ^{99m}Tc -labeled sodium phytate and stannous chloride; ^{99m}Tc -SC, ^{99m}Tc -labeled sulfur colloid.

SLN location is essential in SLNB, often achieved by lymphoscintigraphy or blue dye or their combination, which is confirmed to be of better accuracy compared with lymphoscintigraphy or blue dye alone.^{10,15,30} During decades of development of lymphoscintigraphy technology, various radiopharmaceuticals have been used for SLN localization, and whether the radiopharmaceutical is qualified for SLNB is determined by the anatomical and physiologic features of SLN,²⁶ which means the features, especially the particle size, of radiopharmaceutical should allow for its proper flow velocity in lymphatic vessel and accumulation in SLN for the purpose of better identification of the SLN. A successful SLN localization requires for the right method and site of injection and the right dose as well as particle size, among which particle size is demonstrated to be most crucial.³¹ Particle size is negatively associated with migrate speed and remaining time in SLN, which means a large-sized particle tends to migrate slowly in lymph vessels and remain longer in SLNs.³² In the United States, ^{99m}Tc -SC and ^{99m}Tc -labeled tilmanocept are the most common radiotracers, and both of them are approved by the Food and Drug Administration of the United States,³³ and ^{99m}Tc nano colloid, to be exactly, the colloidal albumin, is preferred by the European surgeons.³⁴

PHY, white powder soluble in water, is used for the preparation of ^{99m}Tc -PHY in clinical practice for years.³⁵ Post injection, phytate reacts with plasma calcium immediately to synthesize soluble colloid with the particle size of 100–1,000 nm, which is similar to that of SC; PHY is approved by the China Food and Drug Administration (CFDA) however the SC is not.³⁵ In the study of Takei et al, ^{99m}Tc -PHY has been proved to be superior to ^{99m}Tc -labeled human serum albumin for SLN detection in patients with breast cancer.³⁶ Similarly, ^{99m}Tc -PHY also demonstrated a better efficiency than ^{99m}Tc -tin colloid in SLNB for breast cancer patients.²⁵ In this study, ^{99m}Tc -PHY showed a more favorable detection rate than ^{99m}Tc -SC; however, no difference of the detected numbers of SLN, sensitivity, specificity, false-negative rate, as well as accuracy rate was found compared with ^{99m}Tc -SC. The probable explanations of our results are: 1) in a previous study, ^{99m}Tc -PHY had a more intense radioactivity in SLNs compared with ^{99m}Tc human serum albumin, indicating PHY had a greater accumulation in the SLN, which might be a specific feature of PHY that is superior to SC;³⁶ 2) the particle size of radiotracer should not be too large to move in the lymphatic vessels, or too small to accumulate in the SLNs, thus it is reasonable that PHY outsourced SC in detection rate with similar or even larger particle size.²⁶

On the other hand, learning curve is another factor that has influence on the accuracy of SLN detection in SLNB. The training

and maturity of the surgeons' skill is essential in SLNB, and using blue dye curtails the learning curve of surgeons in SLNB using ^{99m}Tc.³⁷ A retrospective study elucidated that dye-only injection into the SA plexus had a favorable SLN detection rate in patients with breast cancer.³⁸ In addition, the detection rates by RA alone were numerically lower than that by dye alone in both the two groups, which is partially different from the previous reports, which might be caused by the surgeons who are more skilled in using blue dye than using radiotracers.

Some limitations existed in this study: 1) 146 consecutive female breast cancer patients were recruited in this open-labeled randomized study, the sample size was relatively small which might lead to that differences in some parameters were not observed; 2) surgeon skill was not considered in this study, and it was determined by the stages of learning curve, which was proved to be important in a successful SLNB.³⁹

Conclusion

Our study demonstrated that ^{99m}Tc-PHY was qualified to be a convincing radiopharmaceutical in SLNB.

Acknowledgment

This study was supported by the Special Project for Technical Research and Development of Gansu Province, China (No 3013GS08735).

Disclosure

The authors report no conflicts of interest in this work.

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