

## Original Article



# The Usefulness of Ultrasound Surveillance for Axillary Recurrence in Women With Personal History of Breast Cancer

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## ABSTRACT

**Purpose:** To evaluate the axillary recurrence rate and usefulness of axillary ultrasound (AUS) during supplementary whole-breast ultrasound (US) screening in women with a personal history of breast cancer (PHBC).

**Methods:** A retrospective database search identified consecutive asymptomatic women who underwent postoperative supplemental whole-breast US screening, including that of the bilateral axillae, after negative findings on mammography between January and June 2017. Using the pathologic data or at least 1-year follow-up data as reference standards, the axillary recurrence rate, cancer detection rate (CDR), interval axillary recurrence rate per 1,000 screenings, sensitivity, specificity, and abnormal interpretation rate (AIR) were estimated.

**Results:** From the data of 4,430 women (mean age, 55.0 ± 10.1 years) analyzed in this study, there were five axillary recurrence cases (1.1/1,000) in the median follow-up period of 57.2 months. AUS showed a CDR of 0.2 (1/4,430; 95% confidence interval [CI], 0.01–1.3) and an interval axillary recurrence rate of 0.9 (4/4,402; 95% CI, 0.2–2.3) per 1,000 examinations. The sensitivity and specificity were 20.0% (1/5; 95% CI, 0.5–71.6), and 99.4% (4,398/4,425; 95% CI, 99.1–99.6), respectively, while the AIR was 0.6% (28/4,430; 95% CI, 0.4–0.9%).

**Conclusion:** In asymptomatic women with a PHBC and negative findings on mammography, axillary recurrence after breast cancer and axillary treatment was uncommon, and the supplemental AUS screening yielded 0.2 cancers per 1,000 examinations.

**Keywords:** Breast Neoplasms; Mass Screening; Population Surveillance; Recurrence; Ultrasonography

## INTRODUCTION

Women with a personal history of breast cancer (PHBC) are at risk of developing breast cancer again [1]. Recurrence may occur in the ipsilateral breast or chest wall, regional lymph nodes (LNs), or distant organs. The 5-year recurrence-free survival rate of breast cancer

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**Conflict of Interest**

The authors declare that they have no competing interests.

**Author Contributions**

Conceptualization: Shin SU, Chang JM; Data curation: Shin SU, Chang JM, Park J; Formal analysis: Shin SU, Chang JM, Park J; Funding acquisition: Shin SU, Chang JM; Investigation: Shin SU, Chang JM; Methodology: Shin SU, Chang JM, Park J, Moon WK; Project administration: Shin SU, Chang JM; Resources: Shin SU, Chang JM; Software: Chang JM, Park J; Supervision: Shin SU, Chang JM, Lee HB, Han W, Moon WK; Validation: Shin SU, Chang JM; Visualization: Shin SU, Chang JM, Park J; Writing - original draft: Shin SU, Chang JM; Writing - review & editing: Shin SU, Chang JM, Lee HB, Han W, Moon WK.

patients diagnosed in 2010–2016 was 98.9%, 85.7%, and 28.1% for the localized, regional, and distant cancer stages, respectively, according to the Surveillance, Epidemiology, and End Results program [2]. Regional recurrence is associated with poor prognosis and simultaneous in-breast and distant metastases [3,4].

With the development of adjuvant treatment provided after breast cancer surgery, recent studies have demonstrated low regional recurrence rates of less than 2% [5-7]. Lately, improved outcomes after neoadjuvant chemotherapy (NAC) with improved axillary pathologic complete response rates require less-invasive axillary surgery [8], although there are not enough studies on axillary recurrence in patients treated with NAC and limited axillary surgery.

Because the early detection of second breast cancers in these women improves their prognosis [9], the American Society of Clinical Oncology and the National Comprehensive Cancer Network recommend conducting annual mammography scans for the surveillance of second breast cancer events among women with PHBC [10,11]. However, mammography has been found to have low sensitivity in women with dense breasts [12]. Moreover, due to the limited field of view, detection of regional recurrences in the axillary, infraclavicular, supraclavicular, and internal mammary LNs is challenging with mammography [3].

To overcome the limitations of mammography surveillance, whole-breast ultrasound (US) has been used as a supplemental screening modality [13-15]; however, there are ongoing debates regarding its advantages and disadvantages [16,17]. The scanning of the axillae may be optional during whole-breast US screening according to the American College of Radiology Breast Imaging Reporting and Data System (BI-RADS) Atlas, 5th edition [18]. Notably, a few studies have investigated the role of axillary ultrasound (AUS) surveillance for axillary recurrence in women with PHBC, who underwent sentinel lymph node biopsy (SLNB) or axillary lymph node dissection (ALND) with or without NAC or adjuvant chemotherapy during postoperative whole-breast US screening [19,20]. However, there are no specific guidelines for the inclusion of axillary scanning in US screening.

Therefore, this study aimed to evaluate the axillary recurrence rate and usefulness of AUS during supplementary whole-breast US screening in women with PHBC.

## METHODS

### Patients

This retrospective study was approved by the Institutional Review Board of Seoul National University Hospital (IRB No. 1812-034-991), and the requirement for informed consent was waived due to the nature of this study. For women with PHBC, surveillance-imaging examinations are reimbursed by the Korea National Health Insurance Service for up to 5 years after cancer surgery. Since 2003, our institution has recommended performing both digital mammography and whole-breast US screening on the same day for these patients. Mammography always precedes US, and the bilateral axillary and internal mammary areas are routinely included in the postoperative whole-breast US screening at our institution. We performed a retrospective search of the breast-imaging examinations performed at our institution for women who had undergone breast and axillary surgery for invasive breast cancer. From these patients, we included the asymptomatic women who underwent

postoperative mammography and breast and axillary supplemental US for screening purposes from January to June 2017 and those who underwent histopathologic examination within 1 year for tumor recurrences or had more than 1 year of follow-up data as a reference standard. The exclusion criteria were bilateral breast cancer, initial stage IV cancer, missing histopathological data for the final surgery, positive/good results (BI-RADS assessment category 3 or above) on mammography performed within 1 year of AUS, and no follow-up for at least 1 year.

### Imaging surveillance

Mammography was performed using Selenia Dimensions (Hologic, Bedford, USA) and Senographic2000 DS units (GE Healthcare Systems, Milwaukee, USA), and the findings were interpreted by one of ten board-certified and breast fellowship-trained radiologists according to the BI-RADS lexicon. After reviewing the previous and current mammograms, previous US images, and medical records, bilateral AUS screening examinations were performed as part of the whole-breast screening by one of the ten experienced radiologists with 2–21 years of experience in breast imaging. This was conducted using a 14–16 MHz linear transducer in two machines: Aixplorer US system (SuperSonic Imagine, Aix-en-Provence, France) and EUB-8500 (Hitachi Medical Systems America, Twinsburg, USA). The patient was placed in the supine oblique position with their arm raised above the head. The entire breasts and axillae, including the axillary tail of the breast and internal mammary areas, were scanned. When suspicious LNs were noted, their images in two orthogonal planes (radial/antiradial or transverse/longitudinal) and their maximal cortical thickness measurements were recorded. Color Doppler or elastographic images were obtained when deemed necessary by the radiologist. For a standard AUS examination, representative images of bilateral axillae, including the LNs of axillary levels I, II, and III and internal mammary areas, were documented. Additional scanning of the supraclavicular area was performed when suspicious LNs were present in the axillary or internal mammary areas, which required an additional 1–2 minutes. Additionally, computed tomography (CT), positron emission tomography-computed tomography (PET-CT), and breast magnetic resonance imaging (MRI) were performed for axillary and systemic evaluations when clinically indicated.

### Image analysis

Whole-breast US, including AUS, was performed and interpreted by the same radiologists. Representative images from bilateral breasts and axillae were recorded, the BI-RADS final assessment category was assigned for each breast, and the presence of lymphadenopathy was recorded. Suspicious LNs were defined as having at least one of the following features: focal cortical bulging or eccentric cortical thickening greater than 3 mm, rounded hypoechoic LN, complete or partial effacement of the fatty hilum, and complete or partial replacement of the LN with an ill-defined or irregular mass [21]. The cases having LNs with suspicious features were considered as positive screening results, and short-term follow-up or biopsy was recommended at the radiologist's discretion. If the LNs were interpreted as normal or reactive LNs, those tests were considered as negative screening results. If the cancer tissue diagnosis was not made within a year, the result was considered disease-negative.

### Data collection

Medical records were reviewed to document the patient's age, breast density, clinical and pathologic tumor and node stages, surgical method (mastectomy, breast conservation, SLNB, or ALND), use of NAC and adjuvant therapy, and receptor status (estrogen receptor [ER], progesterone receptor [PR], and human epidermal growth factor receptor type 2

[HER2]). Pathologic data of primary breast cancer (pathologic tumor size and ER, PR, and HER2 receptor status) and LN metastasis were evaluated from the surgical and pathologic reports. Hormone receptor (HR) positivity was defined as ER and/or PR positivity of more than 1% nuclear staining using standard immunohistochemistry methods. HER2 positivity was defined as a HER2 score of 3+ or gene amplification by fluorescence *in situ* hybridization in tumors with a HER2 score of 2+. Tumor subtypes of invasive cancer were categorized as HR-positive/HER2-negative, HR-positive/HER2-positive, HR-negative/HER2-positive, or triple-negative (HR-and HER2-negative).

### Outcome measurements

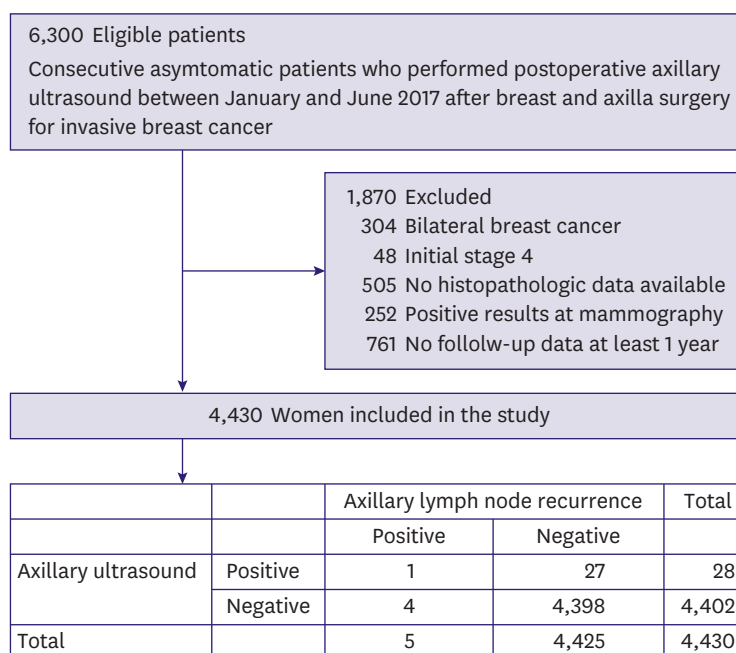
For all women, a medical record review was performed to determine the clinical outcomes during the follow-up period. Axillary recurrence was defined as tumor recurrence in the ipsilateral axillary LNs, which included cases presenting isolated axillary recurrence without local recurrence or axillary recurrence combined with local recurrence. Medical records were reviewed for the date of the last follow-up and for the presence and date of axillary recurrence. Cases showing LNs with suspicious features on AUS with recommendations for short-term follow-up or biopsy were considered as positive screening results. The axillary recurrence rate (number of all cancers per 1,000 screening examinations), cancer detection rate (CDR) (number of cancers detected per 1,000 screening examinations), interval axillary recurrence rate (number of breast cancer diagnoses per 1,000 examinations within 1 year of negative screening examinations but detected by clinical symptoms or imaging abnormalities) were calculated for the breasts and axillae. Additionally, sensitivity (number of positive examinations with a tissue diagnosis of cancer within 1 year of imaging examination divided by all cancers present in the population examined within the same period), specificity (number of negative examinations with no tissue diagnosis of cancer within 1 year of the examination divided by all examinations for which there was no tissue diagnosis of cancer within the same time period), and abnormal interpretation rate (AIR) (number of examinations with positive results divided by the total number of screening examinations) were calculated [22]. The 95% confidence intervals (CIs) for each of these diagnostic performance measures were estimated using the Clopper-Pearson exact CIs. All statistical analyses were performed using SAS 9.4 (SAS Institute Inc., Cary, USA).

## RESULTS

### Patients

In total, 6,300 consecutive women who underwent postoperative US screening of the breast between January and June 2017 after breast and axillary surgery for unilateral operable invasive breast cancer were identified from the Breast Imaging Center database of our institution. Among these women, we excluded those with bilateral breast cancer (n = 304), initial stage IV cancer (n = 48), missing histopathological data for the final surgery (n = 505), positive/good results (BI-RADS assessment category 3 or above) on mammography within 1 year of the last AUS examination (n = 252), and no follow-up for at least 1 year (n = 761). Finally, 4,430 women (mean age  $\pm$  standard deviation, 55.0  $\pm$  10.1 years; range, 24–80 years) were included in this study (**Figure 1**).

The clinical and pathological characteristics of the 4,430 women are presented in **Table 1**. The most common histologic type was invasive ductal carcinoma (91.8%; 4,067/4,430), followed by invasive lobular carcinoma (4.7%; 209/4,430) and other carcinomas (3.5%; 154/4,430). The



**Figure 1.** Flowchart of study participants. Cases showing lymph nodes with suspicious features on axillary ultrasound and those recommended for short-term follow-up or biopsy were considered as positive screening results. The benign lymph nodes were considered as negative screening results. Histological examinations and 1-year follow-up data were used as reference standards.

other carcinomas included mixed invasive ductal and lobular carcinoma, poorly differentiated carcinoma, and metaplastic carcinoma. Among the 936 women subjected to breast cancer surgery with NAC, 9.0% (84/936) of the patients did not have residual invasive cancer.

**Outcomes of US screening**

Five cases of axillary recurrences were identified during a median follow-up period of 57.2 months among the 4,430 women who underwent breast US examinations (1.1/1,000). AUS screening detected one case of axillary recurrence, presenting a CDR of 0.2 (1/4,430; 95% CI, 0.01–1.3) cancers per 1,000 examinations. AUS showed a sensitivity of 20.0% (1/5; 95% CI, 0.5–71.6) and a specificity of 99.4% (4,398/4,425; 95% CI, 99.1–99.6). The interval axillary recurrence rate was 0.9 (4/4,402; 95% CI, 0.2–2.3) cancers per 1,000 examinations and AIR was 0.6% (28/4,430; 95% CI, 0.4–0.9). Biopsy (n = 1) or follow-up (n = 27) was recommended in 28 cases of axillary findings. The detailed screening performance is summarized in **Table 2**.

On the other hand, 16 breast-related recurrences were recorded during a median follow-up period of 57.2 months in the 4,430 women who underwent breast US examinations (3.6/1,000). Whole-breast US screening detected eight breast-related recurrences, showing a CDR of 1.8 (95% CI, 0.8–3.6) cancers per 1,000 examinations. US showed a sensitivity of 50.0% (8/16; 95% CI, 24.7–75.3) and a specificity of 95.8% (4,229/4,414; 95% CI, 95.2–96.4). The interval breast cancer rate was 1.9 (8/4,237; 95% CI, 0.8–3.7) cancers per 1,000 examinations and AIR was 4.4% (193/4,430; 95% CI, 3.8–5.0) (**Table 3**). Eight interval breast cancer cases that were missed were identified by palpable symptoms (n = 4) or other screening examinations, including mammography or MRI (n = 4).

**Table 1.** Patient and tumor characteristics

Characteristics	Values
Age (yr)	55.0 ± 10.1
Breast density	
a	201 (4.5)
b	1,073 (24.2)
c	2,455 (55.4)
d	701 (15.8)
Pathologic T category*	
0	153 (3.5)
1	2,677 (60.4)
2	1,486 (33.5)
3	113 (2.6)
4	1 (0.0)
Pathologic N category*	
0	3,094 (69.8)
1	995 (22.5)
2	259 (5.8)
3	82 (1.9)
Histologic subtype	
Invasive ductal carcinoma	4,067 (91.8)
Invasive lobular carcinoma	209 (4.7)
Others	154 (3.5)
Tumor subtype†	
HR-positive/HER2-negative	2,975 (67.2)
HR-positive/HER2-positive	306 (6.9)
HR-negative/HER2-positive	363 (8.2)
Triple-negative	761 (17.2)
Breast operation type	
Mastectomy	1,671 (37.7)
Breast-conserving surgery	2,759 (62.3)
Axillary operation type	
ALND	1,310 (29.6)
SLNB	3,120 (70.4)
Neoadjuvant chemotherapy	
No	3,494 (78.9)
Yes	936 (21.1)
Adjuvant chemotherapy*	
No	1,977 (44.6)
Yes	2,452 (55.3)
Endocrine therapy*	
No	1,225 (4.7)
Yes	3,205 (95.3)
HER2 targeted agent in HER2-enriched tumors*	
No	242 (36.2)
Yes	427 (63.8)
Breast/Chest wall radiation therapy	
No	1,357 (30.6)
Yes	3,073 (69.4)
Regional nodal irradiation*	
No	3,576 (80.7)
Yes	824 (18.6)

Values are presented as number of women (%) or mean ± standard deviation.

T = tumor; N = node; HR = hormone receptor; HER2 = human epidermal growth factor receptor type 2; ALND = axillary lymph node dissection; SLNB = sentinel lymph node biopsy.

\*For patients who received neoadjuvant chemotherapy prior to surgery, the pathological stage means yp data.

†Only patients with available data were included in the analysis.

**Table 2.** Outcomes of supplemental axillary ultrasound in women with personal history of breast cancer

Parameters	Axillary ultrasonography	
	% (No./Total)	95% CI
Axillary recurrence rate (per 1,000)	1.1 (5/4,430)	0.4–2.6
Cancer detection rate (per 1,000)	0.2 (1/4,430)	0.01–1.3
Abnormal interpretation	0.6 (28/4,430)	0.4–0.9
Interval axillary recurrence rate (per 1,000)	0.9 (4/4,402)	0.2–2.3
PPV3	12.5 (1/8)	0.3–52.7
Sensitivity	20.0 (1/5)	0.5–71.6
Specificity	99.4 (4,398/4,425)	99.1–99.6

PPV3 = the percentage of all biopsies performed that resulted in a tissue diagnosis of cancer within one year of the ultrasound examination.

**Table 3.** Outcomes of supplemental breast ultrasound in women with personal history of breast cancer

Parameters	Breast ultrasonography	
	% (No./Total)	95% CI
Breast recurrence rate (per 1,000)	3.6 (16/4,430)	2.1–5.9
Cancer detection rate (per 1,000)	1.8 (8/4,430)	0.8–3.6
Abnormal interpretation	4.4 (193/4,430)	3.8–5.0
Interval breast cancer rate (per 1,000)	1.9 (8/4,237)	0.8–3.7
PPV3	17.1 (6/35)	6.6–33.6
Sensitivity	50.0 (8/16)	24.7–75.3
Specificity	95.8 (4,229/4,414)	95.2–96.4

PPV3 = the percentage of all biopsies performed that resulted in a tissue diagnosis of cancer within one year of the ultrasound examination.

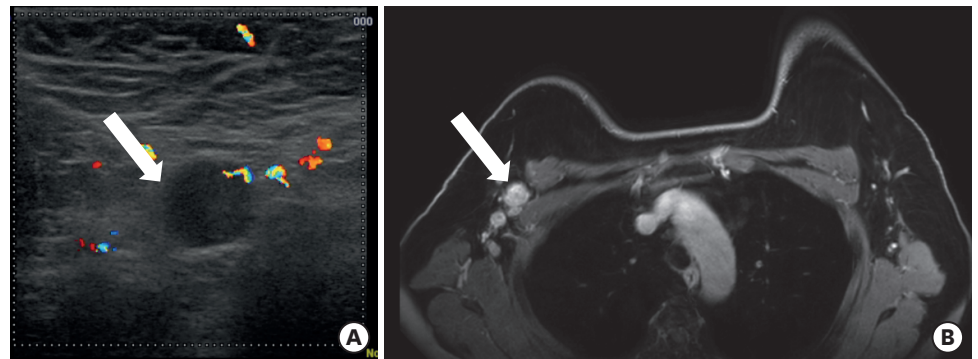
### Characteristics of axillary recurrence

The clinicopathological characteristics of the five axillary recurrence cases are summarized in **Table 4**. Of these, one case was identified on axillary US. The patient underwent breast conservation surgery and SLNB after NAC. Postoperative axillary US screening showed enlarged and round right axillary level I LNs (**Figure 2**) with loss of fatty hilum, and US-

**Table 4.** Outcomes of supplemental breast ultrasound in women with personal history of breast cancer

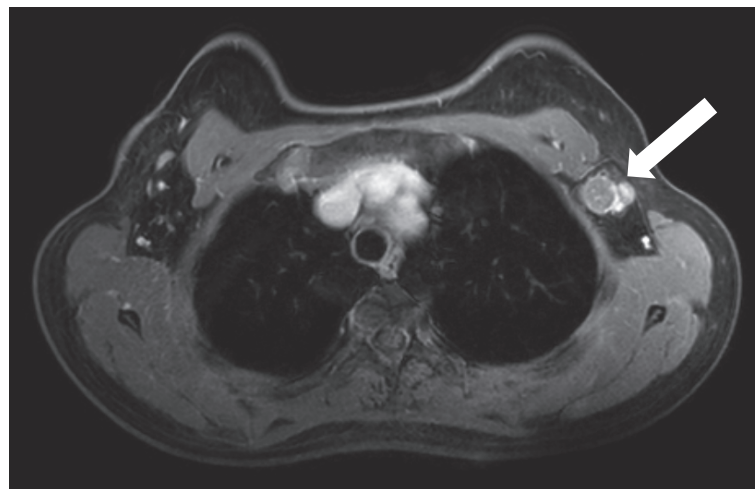
Case No.	Age (yr)	Clinical stage	Neoadjuvant chemotherapy	Breast surgery	Axillary surgery	Pathologic stage	ER/PR*	HER2 <sup>†</sup>	Adjuvant treatment	Detection modality	Level of axillary recurrence	Recurrence-free survival (yr)	Time interval between US and recurrence (mo)	Size of recurred lymph node (mm)
1	48	T2N0	Yes	BCS	SLNB	T1N0	Positive	Negative	Endocrine therapy, breast and axilla radiation therapy	US	Level I	4.01	0	15
2	44	T1N0	No	BCS	SLNB	T1N0	Positive	Negative	None	Palpable mass in the breast and axilla	Level I	0.82	3.14	8
3	45	T4N3	Yes	Mastectomy	ALND	T2N2	Positive	Negative	Chemotherapy, endocrine therapy, chest wall and axilla radiation therapy	PET-CT	Level II	2.08	1.89	6
4	69	T1N1	No	Mastectomy	SLNB	T1N1	Positive	Negative	Chemotherapy, endocrine therapy	Chest CT	Level II	12.39	5.95	22
5	51	T1N0	No	Mastectomy	SLNB	T1N0	Positive	Positive	Endocrine therapy	Chest CT	Level I	3.14	1.39	7

BCS = breast-conserving surgery; SLNB = sentinel lymph node biopsy; ALND = axillary lymph node dissection; T = tumor; N = node; ER = estrogen receptor; PR = progesterone receptor; HER2 = human epidermal growth factor receptor 2; US = ultrasound; PET = positron emission tomography; CT = computed tomography. \*ER/PR was considered positive if either ER-and/or PR-positive. <sup>†</sup>HER2 scores are based on immunohistochemical testing.



**Figure 2.** Images of US-detected axillary recurrence in a 48-year-old woman. (A) Postoperative axillary US screening showed enlarged and round right axillary level I LNs (arrow) with loss of fatty hilum. US-guided core needle biopsy was performed for the LN, and the pathologic analysis revealed metastatic carcinoma. (B) Fat-suppressed contrast-enhanced T1-weighted axial MRI scans reveal suspicious enhancing level I (arrow) LNs in the right axilla. This patient was confirmed to have 10 metastatic LNs among the 17 resected axillary LNs. US = ultrasound; LN = lymph node; MRI = magnetic resonance imaging.

guided biopsy revealed metastatic carcinoma. This patient was confirmed to have 10 metastatic LNs among the 17 axillary LNs resected during surgery. There was no LN metastasis in the initial surgical pathologic report; however, multifocality, high nuclear and histologic grade, and multiple lymphatic emboli were found in the initial surgical pathologic analysis. The other four axillary recurrence cases were not identified on axillary US but by other modalities. Three cases of interval cancers were identified on chest CT (n = 2) or PET-CT (n = 1). In one case, a palpable mass in the left breast and axilla developed 4 months after AUS, and preoperative restaging MRI revealed regional LN recurrence (**Figure 3**). There were two recurrences at level I and two at level II (deep and posterior to the pectoralis minor muscle) of the axillary LNs. In one case, US was performed by a breast radiologist with 2 years of experience, and in the other three cases, US was performed by two experienced breast



**Figure 3.** Images of diagnostic MRI-detected axillary recurrence in a 44-year-old woman. Mammography and axillary US screening conducted 6 months after surgery revealed no abnormalities in the breast and axilla (not shown). A palpable mass in the left breast and axilla developed after 4 months, and a restaging breast MRI was performed. Fat-suppressed contrast-enhanced T1-weighted axial MRI scans show suspicious enhancing level I (arrow) LNs in the left axilla. This patient was confirmed to have 1 metastatic LN among the 28 resected axillary LNs. US = ultrasound; LN = lymph node; MRI = magnetic resonance imaging.



radiologists with 6 and 25 years of experience, respectively. The size of recurrent LNs and the time interval between the latest US screening and recurrence are described in **Table 4**.

## DISCUSSION

Supplemental US screening has been widely used in women with a PHBC; however, the incremental value of supplemental screening AUS in detecting axillary recurrence remains unclear and requires further investigation. According to our study findings, axillary recurrence after breast cancer and axillary treatment was very rare in asymptomatic women with negative mammography results, and postoperative whole-breast US screening, including AUS, was not helpful in detecting axillary recurrence.

Regarding postoperative imaging surveillance for PHBC, the American Society of Clinical Oncology and the National Comprehensive Cancer Network recommend conducting annual mammography scans [10,11], but US screening is not recommended for routine follow-up in an otherwise asymptomatic patient with no specific findings on clinical examination. The American College of Radiology guidelines [23] stated that US screening should be considered only for women at an increased risk of recurrence, who would qualify for but cannot undergo breast MRI; however, whole-breast US screening has been widely used in many countries, including the United States, since the legislation for breast density notification was passed [17,21]. There are no specific guidelines regarding the inclusion of the axilla during US screening, and axillary scanning was optional in the ACRIN 6666 protocol [24]. Supplemental AUS screening may be valuable in women with dense breasts as well as those with fatty breasts in order to compensate for the limited visualization of the deep level I or II axillary LNs on mammography [25]. To date, only a few studies have investigated the role of AUS surveillance in axillary recurrence [19,20].

In our study, the axillary recurrence rate was 1.1 per 1,000 examinations (0.1%). Regional LN recurrence after primary breast cancer treatment has been reported in 0.5%–3.4% of patients after a 10-year follow-up period [26,27]. There have been changes in the surgical management and adjuvant treatment protocols for axillary recurrence in the last few decades, and the axillary recurrence rate after appropriate treatment for early breast cancer is less than 1% [5]. Moreover, we only included a postoperative screening population that was asymptomatic and showed negative findings on mammography; hence, the axillary recurrence may have been less frequent. Surgical or adjuvant treatment was appropriately performed according to the disease status, and we could not identify clinical, pathologic, or imaging factors significantly related to axillary recurrence in our study. Further studies with larger populations are warranted to confirm the predisposing factors related to axillary recurrence previously reported in other studies [7].

Another remarkable finding in our study is that the sensitivity of AUS was extremely low as compared to that of US for the detection of local recurrence. This is similar to the result of another study [6], in which only 3% of axillary recurrences were detected on follow-up imaging. In contrast, a study that evaluated the performance of AUS in the early 2000s reported a sensitivity of up to 78% [20]. The incidence of axillary recurrence in that study [20] was 2.1% among the participants, which is a 20-fold higher rate than that of our study. However, the more recent results from our group in different study periods also showed an overall low CDR of 1.2–1.4 recurrences per 1,000 screens for axillary recurrence [16,19]. Small

metastases without enlargement of the LN or replacement of the fatty hilum can appear normal on US [28]. Furthermore, postoperative anatomical distortion at the surgical site could induce a poor sonic window to detect abnormal LNs. In our study, 80% of the axillary recurrences were detected by other imaging modalities, including chest CT, breast MRI, and PET-CT. Improved overall survival can be expected after axillary recurrence in a group of asymptomatic patients [6]. Given the low prevalence with an unsatisfactory yield of AUS for axillary recurrence, active surveillance with other modalities such as chest CT or breast MRI for selective populations at a high risk of axillary recurrence could be considered. However, intensive imaging surveillance can increase medical costs, and the use of CT or PET-CT for screening modalities raises concerns about additional radiation risks [29].

This study has several limitations. First, this was a single-center, retrospective analysis. Second, US was performed by 10 different radiologists with a wide range of experience. We acknowledge that there could be variability in reader performance according to experience. However, interobserver variability assessment using static US images was not possible because the radiologist who performed US only stored those images with representative or suspicious findings, and normal images were stored as cases with negative screening results. A prospective study is needed to validate our study results further. Third, our results may not be generalizable to community-based US screening performed by technologists or less-experienced physicians or by using automated breast US. Fourth, the patients included in our study received different treatments at different periods, which might have affected the recurrence rate in our study population.

In conclusion, in asymptomatic women with a PHBC and negative findings on mammography, axillary recurrence after breast cancer and axillary treatment was uncommon, and supplemental screening axillary ultrasound yielded 0.2 cancers per 1,000 examinations.

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