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Original article

The diagnostic accuracy of mammography and ultrasonography for recurrent breast cancer after breast conserving treatment[1]

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ABSTRACT

Objective: To evaluate the performance of mammography and breast ultrasonography to diagnose tumor recurrence in patients after breast conserving therapy.

Material and Methods: Imaging findings of 130 breast cancer patients treated by breast conserving therapy (BCT) who have followed up with mammography and ultrasonography at our center between 1 st January 2010 and 1st January 2016 were interpreted by two radiologists. The information of recurrent tumor and baseline data were blinded. Imaging interpretation followed the ACR Breast imaging-reporting and data system (BI-RADS) 5th edition guideline. Findings of mammography, breast ultrasonography, demographic data and histological data were recorded and analyzed.

Results: The presence of mass in mammography (P-value=0.025) and internal vascularity in mass in ultrasonography (P-value<0.001) were associated with recurrent tumor at the surgical bed. All the recurrent tumors were interpreted as BI-RADS 4 (71 patients) with sensitivity= 100%, specificity= 89.5%. BIRADS4 is significant in the diagnosis of recurrent breast cancer in BCT patients (AUC of the ROC curve = 0.742 and 95% CI= (0.7–0.79)).

Conclusion: The presence of mass in mammography and internal vascularity in the mass in ultrasonography are the imaging findings which were significantly related to recurrent tumor at surgical bed in patient with breast conserving treatment.

1. Introduction

Breast cancer is the most common cancer among women [1]. The incidence and prevalence of breast cancer have increased over time [1]. In the past, patients with a diagnosis of early-stage breast cancer underwent modified radical mastectomy (MRM) as a standard surgical management. However, the current standard treatment option for early-stage breast cancer is lumpectomy followed by whole breast radiation [2–4], also known as breast-conserving treatment (BCT). This shift has happened because the National Surgical Adjuvant Breast and Bowel Project (NSABP) B-06 trial demonstrated no difference in the survival time between lumpectomy followed by radiation and radical mastectomy[5]. Thus, the more invasive mastectomy has fallen in popularity.

Approximately 10–15% of patients underwent BCT for operable breast cancer develop locoregional recurrence within 10 years [6–8]. Thus, cancer detection in this patient group is of paramount importance. The BI-RADS categories are the standard assessment categories for breast masses in mammography, ultrasonography and magnetic resonance imaging (MRI). Each category corresponds with a certain probability range that the mass will be a malignancy. These categories are applied to patients who have not undergone breast operations as well as post-BCT patients.

However, application of BI-RADS categories to post-BCT patients is sometimes problematic because of the difficulty of distinguishing scar tissues from ipsilateral breast tumor recurrence (IBTR)[9,10], as scars

[1] Office of The Khon Kaen University Ethics Committee in human research KKU EC approved this study with trial number "HE641099″

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are usually spiculated in shape and thus resemble malignant tissues. Surgical materials and various post-operative changes, such as fat necrosis, hematoma, and infection of surgical bed can also mimic a recurrent cancer.

In developed countries, MRI is often used to circumvent the problem. However, MRI is not easily accessible nor affordable in many undeveloped and developing countries [11]. The breasts of Southeast and East Asians also differ from those of Western ethnic groups due to their small sizes and the resulting denseness (high volume of breast tissue relative to fat tissue)[12]. Therefore, the mammographic and ultrasonographic findings of East Asian breasts may more closely resemble recurrent cancer than those in Western countries, resulting in higher false positive rates in BI-RADS.[13,14].

As a result, many post-BCT patients have received the assessments of BI-RADS categories 4 or 5, which requires imaging-guided biopsies. This overestimation causes many backlogs and long waiting period, which may potentially affect the outcomes of patients. Hence, it is crucial to determine whether the sensitivity and the specificity of BI-RADS categories remain true for post-BCT patients as for patients who have not undergone breast surgery.[14].

2. Materials and methods

This is a retrospective analytical study. The local IRB approved this study with waiver of informed consent.

2.1. Study population

Patients with breast cancer treated by BCT in a single tertiary hospital who underwent 4–12 months post-operative follow-up with mammography and ultrasonography of the breasts between 1th January 2010 and 1th January 2016. The surgical bed lesions were assessed with the BI-RAD system. All patients must have biopsy proven diagnosis or imaging follow up for at least 5 years.

The exclusion criteria are patients with breast cancer and treated by radical mastectomy, mastectomy, lumpectomy without radiation therapy, or conservative treatment, patients with breast implant at cancer side, patients with inadequate imaging study, and with inadequate pathological report.

2.2. Data collection

Basic demographic data were collected from OPD cards and Electronic Medical Records of the hospital. Age (at imaging performed), sex, underlying disease, date of death or alive, cause of death (if there is a record), history of treatment (tumor resection, radiation or chemotherapy), histological findings of the tumor (type, grade, presence of lymphovascular invasion, immunohistochemical staining of ER, PgR, Her-2 or KI-57) were recorded.

The presence or absence of recurrent tumor was diagnosed by a pathological report. If the patient has not undergone tissue diagnosis procedure, imaging follow-up with no evidence of recurrent tumor for 5 years and the last mammography and ultrasonography reports of BI-RADS 2 or 3 was considered to be no recurrent tumor.

These data were concealed to the radiologist who interpreted images.

2.3. Imaging protocol

Mammography was performed using 2 machines, Digital breast Mammogram and Digital breast Tomosynthesis (with C-view Synthesized 2D image), (Hologic® Selenia® Dimensions, Marlborough, MA, USA). The routine digital mammogram with craniocaudal (CC) and mediolateral (MLO) views of both breasts are performed. Additional tomography or special positions were considered for each patient as appropriate.

Ultrasonography of breasts were evaluated using 2 machines which are 1) Shear wave Elastography Ultrasound machine, Supersonic Imagine (AIXPLORER), (Centre d'Affaires Medical, Montreuil, France) and 2) Aloka Prosound Alpha 7, Diagnostic ultrasound machine, (Hitachi Aloca Medical America, Wallingford, CT, USA). The 12–5-MHz transducers were used by radiologists.

2.4. Image analysis

All mammograms and ultrasonographic images were analyzed retrospectively by consensus of two radiologists (specialized in breast imaging & intervention, one has an experience of breast imaging more than 10 years and the other 1 year). The images were reviewed on a commercial workstation equipped with a picture archiving communication system (PACS) monitor with the ability to adjust to the optimal window setting for each case. The radiologists were blinded with patients' information and recurrent outcomes.Visual assessment of ultrasonographic and mammographic findings followed by ACR BI-RADS classification 5th edition[14] at the surgical bed region. The maximal longitudinal diameter of the suspicious mass was measured on PACS. The location of the surgical bed region was divided into inner or outer in CC view and upper or lower in MLO view.

Radiologists evaluated mammograms and ultrasonograpm at the first follow-up study after full course treatment of BCT which was within 4–12 months.

3. Statistical analysis

Continuous variables, including age, diameter of tumor and diameter were tested by using independent sample t-test or Mann-Whitney U test as appropriate. Categorical variables, site of tumor, tumor location, tissue histologic type, grade of tumor, presents of lymphovascular invasion, special staining in pathological report, mammographic and ultrasonographic findings were tested with Pearson's Chi-square or Fisher's exact test.

The correlation between BI-RADs assessment and the presence of recurrent tumor was analyzed using prevalence, sensitivity, specificity, ROC area, likelihood ratio, positive and negative predictive values with 95% confidence interval. The correlation between other recorded data such as imaging findings and histological findings and the presence of recurrent tumor was also evaluated using Odd ratio (95% CI) and P-value. The P-value < 0.05 is considered significant difference.

All statistical analyses were performed using SPSS version 10.0.

4. Results

4.1. Baseline data

In total, 130 patients were included in this study. The median age of the patients is 49.75 (ranging 27–70 years). Surgical bed is almost equally distributed at right and left side, 51.2% (66 patients) and 48.8% (64 patients), respectively.

Before treatment with BCT, the tumor mainly located at upper outer region (53.0%), followed by upper inner region (12.8%). The tumor size of the patients is approximately 2 cm in average (ranging 0.2–1.0 cm in longitudinal length).

Most of the tumors are invasive ductal carcinoma, not otherwise specified IDC NOS = 74.4%, IDC with other subtypes = 8.5%, followed by ductal carcinoma in situ DCIS (8.5%) and then invasive lobular carcinoma ILC (2.6%). The other invasive breast cancer type including infiltrative ductal carcinoma, metaplastic carcinoma, mucinous adenocarcinoma and squamous cell carcinoma are about 6.0%. Most of the tumor (not including DCIS) are classified as Grade 2 (60.4%). About 77.4% of tumor are reported to have no evidence of lymphovascular invasion by histology. The records of ER, PgR, HER-2 and KI-57 immunno-histochemical staining were shown in Table 1. Only 9 out of

Table 1
Baseline data.

Characteristics	n
Age (Mean (SD))	49.75 (10.21)
Tumor size (cm) (Median (IQR))	2 cm (range 1.3–3)
Sides	
Right breast	66 (51.16)
Left breast	64 (49.69)
Tumor location (quadrant)	n = 117
Upper outer	62 (52.99)
Upper inner	15 (12.82)
Upper mid	10 (8.55)
Other	30 (22.19)
Pathological findings of primary cancer	
Tissue histology type	n = 117
IDC NOS*	87 (74.35)
IDC with other subtypes	10 (8.5)
ILC	3 (2.56)
DCIS	10 (8.54)
Other types	7 (5.95)
Grade	n = 100
1	16 (15.84)
2	61 (60.40)
3	22 (21.78)
4	1 (0.99)
Positive lymphovascular invasion	24 (22.64)
Positive ER staining	79 (73.83)
Positive PgR staining	73 (68.22)
Positive Her-2 staining	35 (32.71)
Positive Ki-67 staining (%)	20 (10–30)

* IDC=invasive ductal carcinoma, NOS=non otherwise specified, ILC=invasive lobular carcinoma, DCIS=ductal carcinoma in situ

130 patients were record death.

4.2. Mammographical and ultrasonographical findings in BCT

As shown in Table 2, detection rate of mass by mammography is 37.9% whereas that by ultrasonography is 65.9%. The minimum size of mass detection is 1.2 cm in both mammography and ultrasonography. However, the average size of mass detected by mammography is 2 cm, larger than that by ultrasonography (1.6 cm).

4.3. Logistic regression for association between tumor recurrence and actors

From overall Mammogram and ultrasound findings assessment at surgical bed region found that the presence of mass by mammography (P-value=0.025), presence of internal vascularity in mass by ultrasonography (P-value<0.001), presence of lymphovascular invasion by histopathological finding (P-value =0.04) and the biopsy rate (0.006) are associated with tumor recurrence at the surgical bed. (Table 3) Other findings such as the size of tumor, shape, margin, orientation, echogenicity, posterior features, vascularity, calcification show no significant difference.

Among 130 patients, 71 (54.6%) were diagnosed as BI-RADS 4 (4 A=20, 4B=49, 4 C=2). 46 (35.4%) were BI-RADs 2, and 13 patients (0.1%) were BIRADS 3.

34 patients were biopsied and 21.4% in this group have pathologically proven recurrent tumor. One patient did not received biopsy at BCT, but recurrence of the tumor was found during follow up. Additional

Table 2
Mammography and ultrasonography findings at the surgical site after BCT.

	Mammography - n (%)	Ultrasonography - n (%)
Mass		
No	82 (62.12)	45 (34.09)
Yes	50 (37.88)	87 (65.91)
Size (Median (IQR))	2 (1.2 – 3.4)	1.6 (1.2 – 2.6)

Table 3
Logistic regression for association between Recurrent tumor and Factors (Demographic, Mammogram and ultrasound findings).

Factors	No Recurrence	Recurrence	Odds ratio (95%CI)	p-value
Age	49.93 (10.40)	46.85 (7.13)	0.97 (0.90 – 1.05)	0.442
Tumor size (cm)	2 (1.3–3)	2 (1.7 – 2)	0.77 (0.33 – 1.80)	0.542
Primary tumor pathological findings				
Positive lymphovascular invasion	20 (20.41)	4 (57.14)	5.2 (1.08 – 25.13)	0.040
Positive ER staining	74 (74.75)	5 (71.43)	0.85 (0.15 – 4.63)	0.846
Positive PgR staining	69 (69.70)	4 (57.14)	0.58 (0.12 – 2.75)	0.493
Positive Her-2 staining	32 (32.32)	2 (28.57)	0.84 (0.15 – 4.55)	0.837
Positive Ki-67 staining (%)	20 (10–30)	30 (10 – 50)	1.01 (0.98 – 1.05)	0.519
Mammographical findings				
Visible mass	42 (33.87)	6 (85.71)	11.71 (1.37 –100.51)	0.025
Size (cm)	2 (1.3 –3.4)	1.6 (1.1–2.4)	0.89 (0.50 – 1.61)	0.707
Shape				
Round	2 (4.65)	1 (16.67)	1	
Oval	10 (23.26)	0 (0.00)	1	
Irregular	31 (72.09)	5 (83.33)	0.322 (0.02 – 4.26)	0.390
Margin				
Circumscribe	7 (16.28)	0 (0.00)	1	
Obscured	2 (4.65)	0 (0.00)	NA	NA
Microlobulated	1 (2.33)	0 (0.00)	NA	NA
Indistinct	1 (2.33)	1 (16.67)	6.4 (0.34 – 119.58)	0.24
Spiculated	32 (74.42)	5 (83.33)	NA	NA
Density				
Hyperdensity	28 (65.12)	6 (100.00)	NA	NA
Hypodensity	-	-	NA	NA
Fat	15 (34.88)	0 (0.00)	NA	NA
Calcification				
No	44 (89.80)	6 (85.71)		
Benign	5 (10.20)	0 (0.00)	NA	NA
Suspicious	0 (0.00)	1 (14.29)	NA	NA
Scar appearance				
No	7 (5.83)	0 (0.00)		
Yes	113 (94.17)	7 (100.00)	NA	NA
Skin thickening				
No	10 (8.40)	0 (0.00)		
Yes	109 (91.60)	7 (100.00)	NA	NA
Ultrasonographical findings				
Mass	80 (64.52)	6 (85.71)	3.3 (0.38 – 28.29)	0.276
Size (cm)	1.6 (1.2 –2.6)	1.55 (1 – 2.1)	0.98 (0.54 – 1.80)	0.955
Shape				
Round	25 (31.25)	1 (16.67)	1	
Oval	12 (15.00)	1 (16.67)	2.08 (0.12 – 36.23)	0.614
Irregular	43 (53.75)	4 (66.67)	2.33 (0.25 – 21.98)	0.461
Margin				
Circumscribe	29 (36.25)	1 (16.67)	1	
Obscured	6 (7.50)	1 (16.67)	4.83 (0.26 – 88.53)	0.288
Microlobulated	3 (3.75)	0 (0.00)	NA	NA
Indistinct	5 (6.25)	1 (16.67)	5.8 (0.31 – 108.60)	0.240
Spiculated	37 (46.25)	3 (50.00)	2.35 (0.23 – 23.80)	0.469
Orientation				
Parallel	47 (58.75)	3 (50.00)	1	
Not parallel	33 (41.25)	3 (50.00)	1.42 (0.27 – 7.50)	0.676
Echogenicity				

(continued on next page)

Table 3 (*continued*)

Factors	No Recurrence	Recurrence	Odds ratio (95%CI)	p-value
Anechoic	9 (11.25)	0 (0.00)	1	
Hyperechoic	2 (2.50)	0 (0.00)	NA	NA
Isoechoic	5 (6.25)	1 (16.67)	4.2 (0.22 – 79.32)	0.338
Hypoechoic	38 (47.50)	3 (50.00)	1.66 (0.16 – 16.96)	0.670
Heteroechoic	5 (6.25)	1 (16.67)	4.2 (0.22 – 79.32)	0.338
Complex solid cystic	21 (26.25)	1 (16.67)	NA	NA
Posterior features				
No features	21 (26.25)	0 (0.00)	1	
Enhance	13 (16.25)	0 (0.00)	0.69 (0.06 – 8.47)	0.773
Shadow	26 (32.50)	3 (50.00)	1.04 (0.16 – 6.86)	0.969
Combine	18 (22.50)	2 (33.33)	NA	NA
Vascularity				
Absent	77 (96.25)	1 (16.67)	1	
Internal	2 (2.50)	5 (83.33)	192.5 (14.8–2503.19)	< 0.001
Rim	1 (1.25)	0 (0.00)	NA	NA
Calcifications	1 (1.02)	0 (0.00)	NA	NA
Scar				
No	8 (6.78)	1 (14.29)	1	
Yes	110 (93.22)	6 (85.71)	0.44 (0.05 – 4.08)	0.467

pathological findings by biopsy at the surgical bed lesion revealed that all the recurrent tumor of BI-RADS 4 patients were invasive ductal carcinoma (some has DCIS component or post chemotherapy change). The benign pathological findings are fat necrosis (10 cases) (Fig. 5), granulation tissues (6 cases), fibrous stroma (5 cases), chronic inflammation (4 cases) and fibrocystic change (3 cases).

4.4. Diagnostic test for recurrent tumor

All 71 (54.6%) out of 130 patients who were diagnosed of BI-RADS 4 at surgical bed region were considered to have pathologically proven recurrent tumor by biopsy. All the recurrent tumor were found in BI-RADS 4. The sensitivity is 100% but specificity is 89.5%. The positive predictive value is about 9.86%. Likely hood ratio for recurrent tumor is approximately 1.04. (Table 4).

The sensitivity and specificity of the diagnostic values of of the BI-RADS 4 subgroups are given in Table 4. Only BI-RADS 4 is significant in diagnosis of recurrent breast cancer at BCT; AUC of the ROC curve = 0.742 and 95% CI= (0.7–0.79).

4.5. Post-test probability

From the likelihood ratio graph (Fig. 1), the positive post-test probability in diagnosis of BI-RADS 4 is 10%, BI-RADS 4B is 10% and BI-RADS 4 C is 67%. Post-test probability of BI-RADS 4 A cannot be assessed because there is no case of recurrent tumor in this subgroup.

5. Discussion

From this study in post-BCT patients of this hospital, only BI-RADS 4 (including all 4 A,4B and 4 C cases) is significant to diagnose the recurrence of tumor (AUC of the ROC curve > 0.7, sensitivity 100% and specificity 89.5%, post-test positive predictive value 10%) and the result is compatible with BI-RADS 4 in ACR classification (probability of malignancy 2–94%)[14]. However, we are unable to evaluate the post-test predictive value in BI-RADS 4 A because there is no case of recurrent tumor in this category (diagnosed as BI-RADS 4 A; n = 20) which may because of too small sample size of this study. Another possibility is that according to the ACR BI-RADS 5th edition[14] BI-RADS 4 A is for non-surgical intervention lesion. Some benign lesion which seen in post-BCT with the appearance suspicious for malignancy following ACR guideline may cause more interventional surgery than necessary (Fig. 2). BI-RADS 4B (positive post-test probability 10%, sensitivity 71.4%, specificity 32.8%) is just at lower range of probability of malignancy in moderate suspicious for malignancy ACR BI-RADS 5th edition (10%-<50%). The percent of probability of the recurrence in this study is quite low may be because the same reasons as BI-RADS 4 A (Fig. 3). BI-RADS 4 C (positive post-test probability 67%, sensitivity 28.6%, specificity 98.4%) is compatible with the range of probability of malignancy in ACR BI-RADS 5th edition (50%-<95%) (Fig. 3). BI-RADS 4 C is high suspicious of malignancy but not classical finding of malignancy and the malignant results are expected at biopsy (Fig. 4). This study does not have the lesion with BI-RADS 5 which could be due from no malignant feature of calcification and the appearance of scar combine within tumor causing radiologist considered to be lower BI-RADS interpretation.

This study revealed that the presence of a mass in mammography (P-value=0.025), the presence of internal vascularity in the massby ultrasonography (P-value<0.001) and the presence of lymphovascular invasion by histopathological examination (P-value =0.04) are associated with the recurrence of tumor at the surgical bed. These findings are compatible with other studies such as Subhash et al. [13] describe the worrisome feature in mammography as the visualized increase in size and the density of mass at the surgical bed, the increase in number of suspicious microcalcification, the increase of skin thickening, and new axillary lymphadenopathy. Esen et al. [15] found that post treatment changes usually are avascular after approximately 6 months, whereas recurrent tumors often have demonstrable vascularity. However, granulation tissue that develops in the walls of the cavity also has demonstrable blood flow in the first 6 months after surgery. Lymphovascular invasion obviously suggest that the tumor is infiltrating into the vascular system and has higher probability of recurrence.

Most common benign lesions are biopsied lesion (10 lesions, 28%) and granulation tissue (6 lesions, 21%) which are difficult to distinguish from recurrent tumor. The presence of fat density within the mass and the presence of dystrophic calcification are suggestive of the presence of fat necrosis[16]. However, granulation tissue is quite difficult to differentiate from recurrent tumor [15].

The ER, PR, HER-2 and KI-57 positivities are not related to the rate of recurrent tumor, which could be attributed to too small of sample size.

Table 4
Diagnostic test of BIRADS classification and recurrence of tumor.

	BIRADS 2	BIRADS 3	BIRADS 4	IF BIRADs 4 (n = 71)		
				A	B	C
Sensitivity (%)	0 (0–41)	0 (0 – 41)	100 (59–100)	0 (0–41)	71.4 (29 – 96.3)	28.6 (3.67–71)
Specificity (%)	62.1 (52.9 – 70.7)	89.5 (82.7 – 94.3)	48.4 (39.3 – 57.5)	68.8 (55.9 – 79.8)	32.8 (21.6 – 45.7)	98.4 (91.6 – 100)
AUC of the ROC curve	0.31 (0.27 – 0.35)	0.448 (0.42 – 0.48)	0.742 (0.7 – 0.79)	0.344 (0.29 – 0.4)	0.521 (0.33 – 0.71)	0.635 (0.45 – 0.82
Likelihood ratio (+)	0 (NA)	0 (NA)	1.04 (1.63 – 2.3)	0 (NA)	1.06 (0.65 – 1.75)	18.3 (1.89 – 1.77)
Likelihood ratio (-)	1.61 (1.4 – 1.85)	1.12 (1.05 – 1.19)	0 (NA)	1.45 (1.23 – 1.72)	0.871 (0.256 – 2.96)	0.726 (0.45 – 1.16)
Positive predictive value (%)	0 (0 – 7.55)	0 (0 – 24.7)	9.86 (4.06 – 19.3)	0 (0 – 16.8)	10.4 (3.47 – 22.7)	66.7 (9.43 – 99.2)
Negative predictive value (%)	91.7 (83.6 – 96.6)	94.1 (88.2 – 97.6)	100 (94 – 100)	86.3 (73.7 – 94.3)	91.3 (72 – 98.9)	92.6 (83.7 – 97.6)

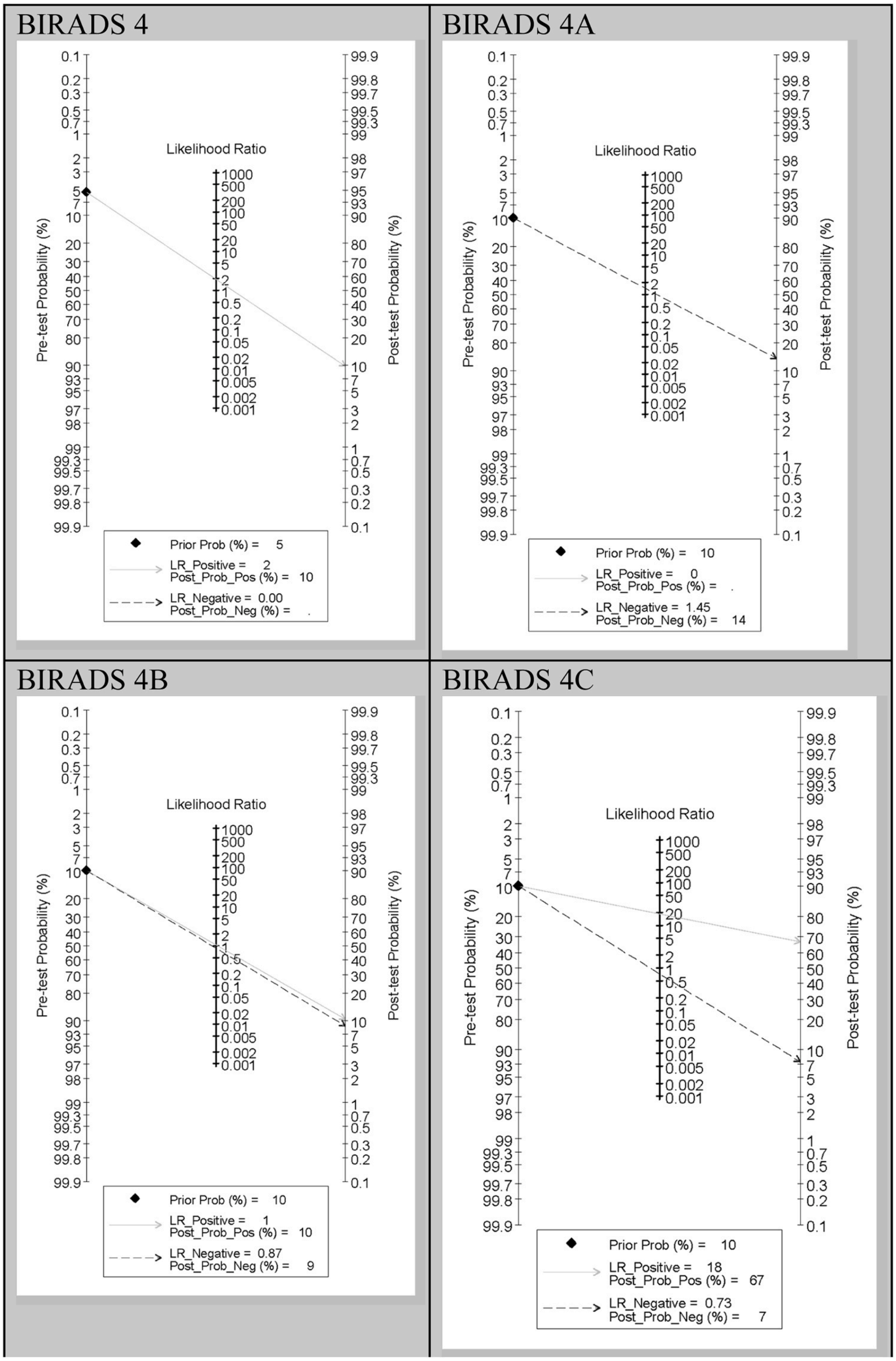

Fig. 1. Post-test probability.

There are some study showing that triple negative breast (TNBC) cancer which is usually more high-grade tumor than non-triple negative breast cancer (non-TNBC) was not associated with poor clinical outcome in term of locoregional recurrence-free survival and overall survival[15]. In this study, we cannot evaluate the survival outcome because there is only 9 out of 130 patients died by canncer (too small population).

In conclusion, the presence of mass in mammography (P-value=0.025), presence of internal vascularity in tumor mass in ultrasonography (P-value<0.001) and the presence of lymphovascular invasion in histopathological observation finding (P-value =0.04) are highly associated with the recurrence of tumor at the surgical bed. Using ACR BI-RADS 5th guideline to interpret recurrent tumor in post BCT patients at the surgical site, BI-RADS 4B (positive post-test probability 10%, sensitivity 71.4%, specificity 32.8%) and BI-RADS 4 C (positive post-test probability 67%, sensitivity 28.6%, specificity 98.4%) are helpful for evaluation. However, in this study, predictivity of BI-RADS 4 A for recurrent tumor is not validated, may be due to insufficient number of study samples. For this group, caution is needed for misleading to unnecessary biopsy.

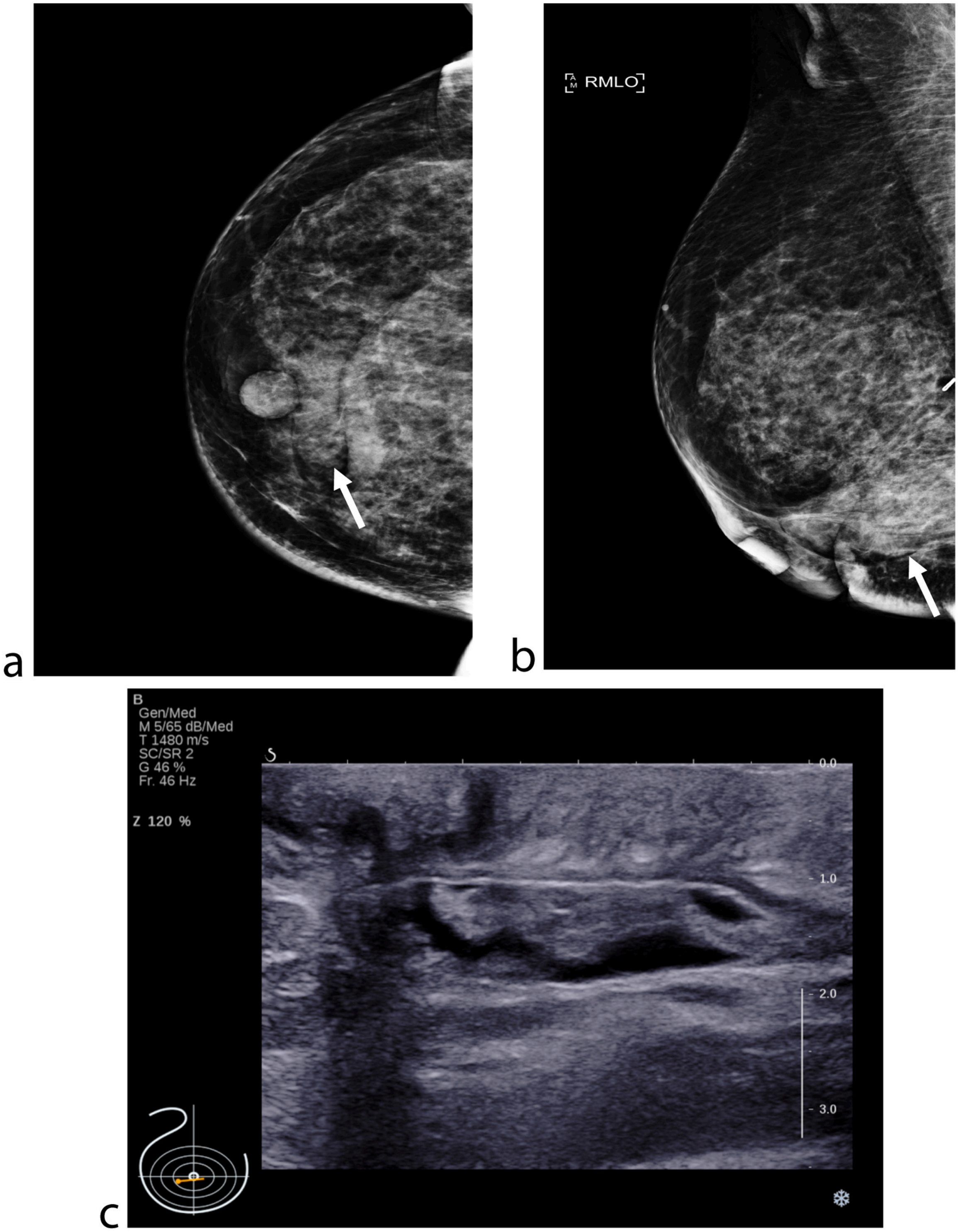

Fig. 2. A 41-year-old woman with right breast cancer underwent right BCT. The post-operative mammogram (a, b) of right breast showed heterogenous dense breast with post-BCT change with skin thickening, architectural distortion with an isodense mass (arrowed) with indistinct border at subareolar region. Ultrasound (c) found a complex solid-cystic mass about 4.0 × 1.0 cm at surgical bed. The lesion was interpreted as BIRADS 4B. The pathological exan of biopsy has proven this lesion as granulation tissues.

6. Recommendation

- Although the number of participants in this study (130 patients) reached the required number (106–165 patients) by calculation, evaluation of BI-RADS 4 A or other significant findings remains inadequate. Further study with larger populations will bring more significant difference among those imaging findings.

- There is still the subjective to evaluate BI-RADS following ACR BI-RADS 5th guideline. However, this study had been discussed and interpreted by consensus between two radiologists, but in other field of radiologist, the ability to interpretation would be different.

- The clinical correlation is still significant for diagnosis the imaging study especially in the BCT patients [16].

- This study has criteria for follow up recurrent tumor up to 5 years

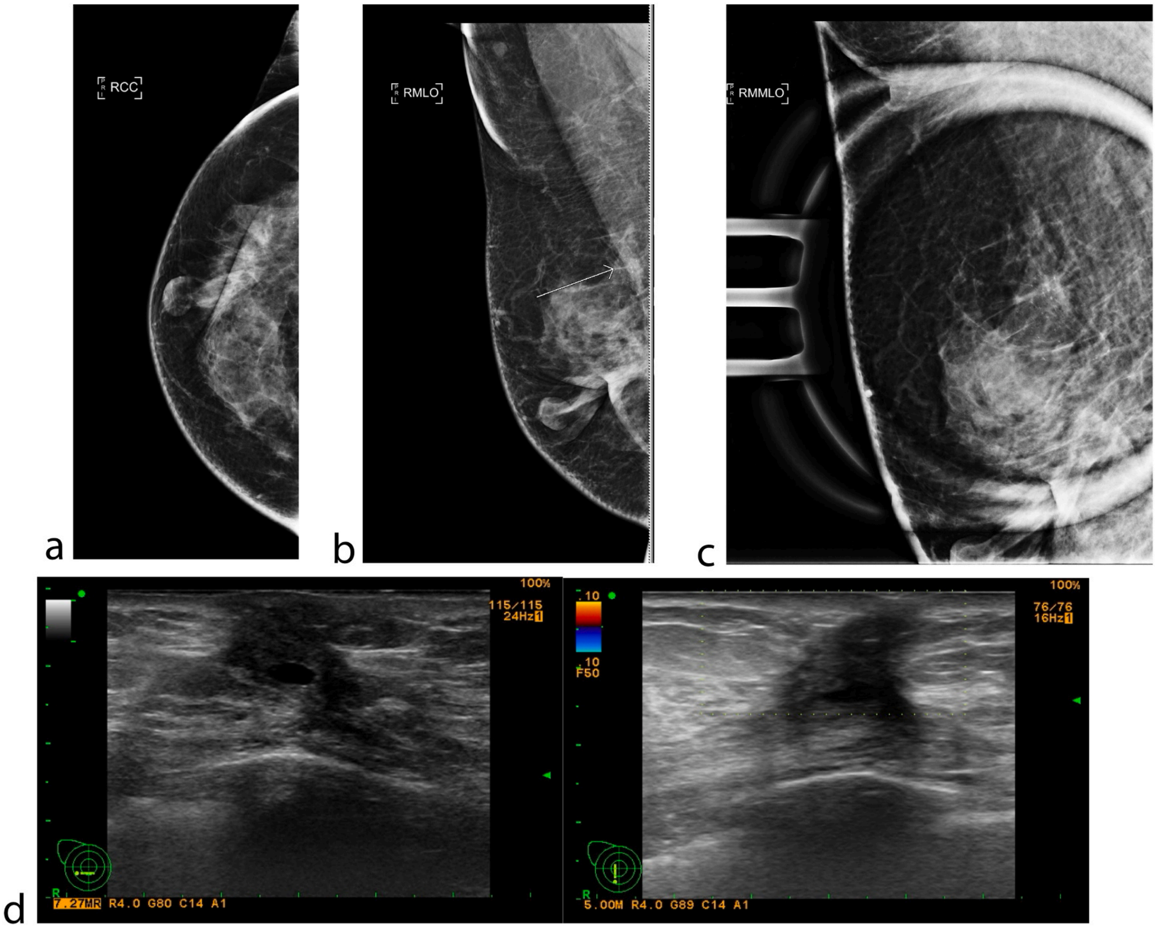

Fig. 3. A 50-year-old woman with right breast cancer underwent BCT with follow up 8 months after complete treatment found a group of pleomorphic calcification with indistinct mass at surgical bed in mammogram and indistinct hypoechoic mass and cystic component in ultrasounds, no evidence of internal flow in this lesion. This lesion was interpreted as BIRADS 4B. Pathological proven; recurrent invasive ductal carcinoma.

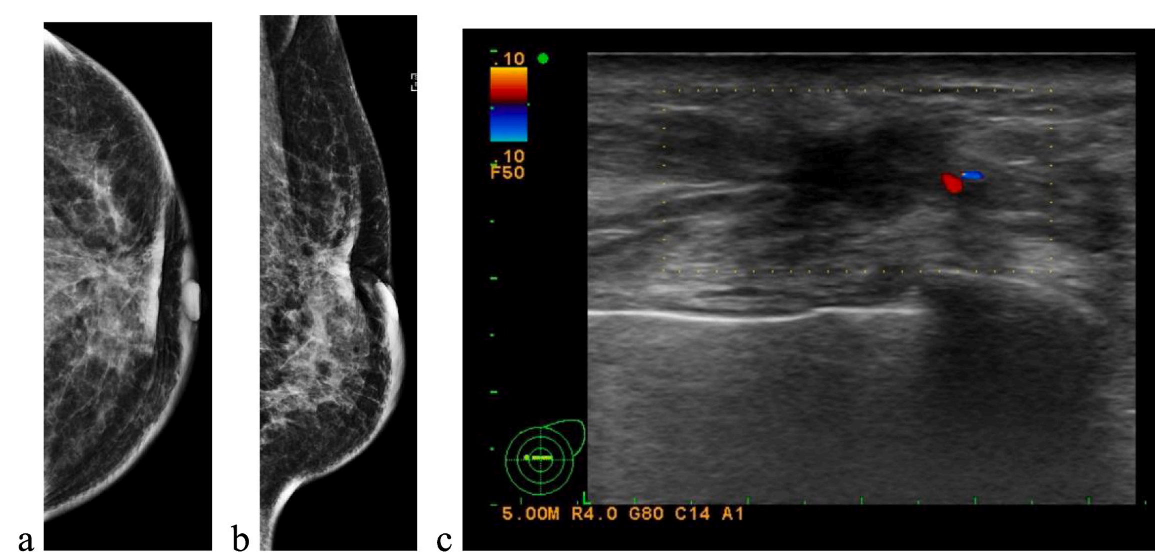

Fig. 4. A 48-year-old woman with left breast cancer post BCT with 2nd follow up Mammogram (1 year after complete treatment) found architectural distortion and hyperdense lesion at surgical bed region (a and b). Ultrasound showed a spiculated hypoechoic lesion with internal flow. BIRADS 4 C was interpreted and biopsied proven recurrent invasive ductal carcinoma with post chemotherapy change.

but there is a study that r tumor ecurrence can appear at the 10 years [6–8]. Extension of the follow up criteria to rule out recurrent tumor could be considered with having adequate population and information.

Ethical approval

All procedures involving human participants were performed in

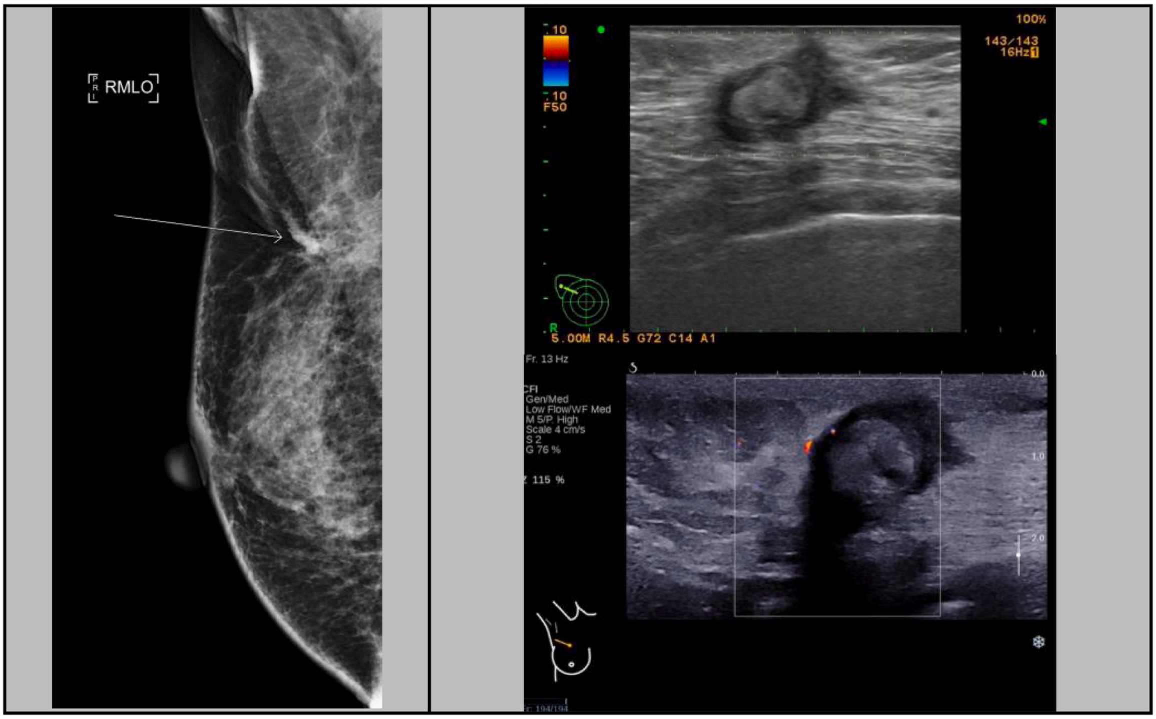

Fig. 5. A 52-year-old woman with right breast s/p BCT follow up mammogram at 10 months after treatment with spiculated combine fat and hyperdense lesion at surgical bed region (upper outer quadrant), ultrasound showed hyperechoic with perilesional hypoechoic lesion with peripheral flow. BIRADS 4B was interpreted and the pathological report from biopsy was fat necrosis.

accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. For this type of report, formal consent is not required. Neither patients nor the public were involved in designing, conducting, reporting, or disseminating this research.

Contributor's statement

PP and AB contributed to the conception or design of the work, revising it critically for important intellectual content and final approval. SN, PC, OS, CA contributed to the conception or design of the work, analysis and final approval.

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CRediT authorship contribution statement

Piyakan Pathanasethpong: Conceptualization, Formal analysis, Supervision, Writing – original draft, Writing – review & editing, Methodology, Validation, Visualization. **Supajit Nawapun:** Conceptualization, Writing – original draft, Writing – review & editing. **Payia Chadbunchachai:** Conceptualization, Writing – original draft, Writing – review & editing. **Ongart Somintara:** Conceptualization, Writing – original draft, Writing – review & editing. **Chaiwat Apivatanasiri:** Conceptualization, Investigation, Writing – original draft, Writing – review & editing. **Arunnit Boonrod:** Conceptualization, Data curation, Formal analysis, Writing – original draft, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Informed consent

Informed consent was not required.

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