Original Article

대한영상의학회지

Radiology Residents' Comprehension of the Breast Imaging Reporting and Data System: The Ultrasound Lexicon and Final Assessment Category
Breast Imaging Reporting and Data System에 대한 영상의학과 전공의들의 이해도: 초음파 검사 표준용어 및 최종평가분류

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Purpose: To evaluate radiology residents' performance in interpretation and comprehension of breast ultrasonographic descriptors in the Breast Imaging Reporting and Data System (BI-RADS) to suggest the adequate duration of training in breast ultrasonography.

Materials and Methods: A total of 102 radiology residents working in the Department of Radiology were included in this study. They were asked to answer 16 questions about the ultrasonographic lexicon and 11 questions about the BI-RADS category. We analyzed the proportion of correct answers according to the radiology residents' year of training and duration of breast imaging training.

Results: With respect to the duration of breast imaging training, the proportion of correct answers for lexicon descriptors ranged from 77.2% to 81.3% ($p = 0.368$) and the proportion of correct answers for the BI-RADS category was highest after three-four months of training compared with after one month of training ($p = 0.033$). The proportion of correct answers for lexicon descriptors and BI-RADS category did not differ significantly according to the year of residency training.

Conclusion: Radiology residents' comprehension of the BI-RADS category on breast ultrasonography was not associated with their year of residency training. Based on our findings, radiology residents' assessment of the BI-RADS category was significantly improved with three-four months of training compared with one month of training.

INTRODUCTION

The demand for breast imaging is increasing as a result of nationwide breast cancer screening. Although mammography is a very useful imaging modality for detecting and diagnosing breast cancer, its sensitivity for detecting breast cancers is reported to be as much as 50% lower in dense breasts (1-3). In recent years, breast ultrasonography (US) has undergone enormous growth and change, which are expected to continue. Therefore, supplemental US for the detection of breast cancer is being widely recommended in women with dense breasts (4-7). As a result, the issue of qualifications required for breast imaging and adequate

curriculum for breast US training has been raised. Nowadays, some countries have established their own training requirements for physicians interpreting mammography (8-10). However, there is a lack of established guidelines for breast US training in radiology residency programs.

The development of resident training guidelines for breast US should be based on actual radiology residents' performance in determining the lesion description and final assessment, for example, their year of residency and the duration of breast imaging training. However, there are few published reports about the actual radiology residents' performance in breast US.

The Breast Imaging Reporting and Data System (BI-RADS) lexicon for US is a quality assurance tool designed to standardize reporting, interpretation and management recommendations (11, 12). Therefore, the BI-RADS is likely to be the most objective tool for assessing the training performance. The purpose of our study was to evaluate radiology residents' performance in interpretation and comprehension of breast US descriptors in order to suggest the adequate duration of training in breast US.

MATERIALS AND METHODS

The Institutional Review Board approved this retrospective study. The study was based on a survey performed at an annual breast imaging conference for educating the radiology residents, which is hosted by the Korean Society of Radiology and the Korean Society of Breast Imaging. This conference is one of the largest meetings on breast imaging–many radiology residents from around the country gather for the breast imaging review. A total of 113 radiology residents who attended the conference in 2014 were enrolled in this study. The main theme of the conference was the fifth edition of BI-RADS, which was released in 2013 (11). The radiology residents were asked to independently complete a survey using a wireless remote control answering machine with a numerical keyboard. Each surveyee's answers were gathered into the mainboard. Prior to conducting the survey, we explained to the radiology residents that the purpose of the survey was to assess their degree of understanding of breast US and to inform conference lecture planning. They were assured that their individual responses would be kept confidential. Among the 113 radiology residents, eleven radiology residents who answered less than three questions were excluded from our

study population. The remaining 102 radiology residents were included in the data analysis.

Questionnaire

We collected US images of 27 breast masses in 27 women from five academic institutions that were obtained between November 2013 and April 2014. Six dedicated breast imaging radiologists specializing in breast imaging with 3–13 years of experience from five institutions performed the ultrasound examinations.

Informed consent was obtained from all of the patients for establishing the image database for radiology resident education and evaluation. Breast masses were examined with one of the institution's US systems (iU22, Philips Medical Systems, Bothell, WA, USA; GE LOGIQ E9, GE Medical Systems, Milwaukee, WI, USA; SuperSonic Imagine, Aix-en-Provence, France; EUB-8500, Hitachi Medical, Tokyo, Japan); each US system being equipped with high-frequency linear array transducers. During scanning, spatial compounding was set on all units and harmonic imaging was used on two units (SuperSonic Imagine and EUB-8500). Representative transverse and longitudinal grayscale images of each mass were acquired and then consensus was reached for each imaging descriptor, and final assessment among the six radiologists was based on the fifth edition of BI-RADS (11). Questions were generated for US lexicon and final assessment categories, and grayscale US images were chosen from the database under the consensus of two radiologists. BI-RADS categories 4C and 5 were grouped into one category (4C and 5) because the clinical management of these two categories is the same and the number of answer choices which could be programmed into the answering machine system was limited to five. The survey consisted of 11 questions about the final assessment categories of BI-RADS (3 questions for category 2, 1 question for category 3, 1 question for category 4A, 2 questions for category 4B, and 4 questions for category 4C and 5) and 16 questions on the US lexicon (3 questions for shape, 2 questions for orientation, 5 questions for margin, 4 questions for echo pattern, and 2 questions for posterior feature). The descriptors of calcifications and associated features including vascularity and elasticity assessment were not included in this survey.

The histopathologic diagnoses of masses for the 11 questions about the BI-RADS category were collected from each institution. We obtained the final histopathology results for each case

by US-guided core needle biopsy (*n* = 10) and US-guided vacuum-assisted biopsy (*n* = 1).

Survey

Before starting the survey, general information, such as their year of residency and duration of breast imaging training they had received during training, was collected. Breast US images were displayed on a large screen in the front of an auditorium for review. For each question, ten seconds were given to watch the images and an additional five seconds to choose the answer from a multiple choice format. Radiology residents answered by using a wireless answering machine in which all answers were collected in a single database for analysis.

Statistical Analysis

The reference standard was based on the consensus among six breast imaging radiologists. The proportion of correct answers according to the BI-RADS US lexicon and the final assessment category was defined as the number of correct answers divided by the total number of responses. No answer was regarded as missing data and it was excluded from the statistical analysis. Among US lexicons, the proportion of correct answers was compared using the chi-square test. The proportion of correct or incorrect answers among radiology residents was also compared according to the year of training or the duration of breast imaging training using the chi-square test. Trends in each of the training duration categories were tested with the use of linear by linear association test (Mantel-Haenszel trend test). We performed a post-hoc analysis for evaluation of significant differences according to the duration of breast imaging training. The results were expressed as percent-

ages and raw numbers. *p*-values less than 0.05 were deemed to indicate statistical significance. Statistical analysis was performed using statistical software (SAS version 9.2; SAS Institute, Cary, NC, USA).

RESULTS

After the survey, a total of 2343 answers were obtained, which were 79.2% of the 2958 expected answers. On average, 21 questions were answered (median, 24; range, 7–27) by each participant. Of the 77 participants who gave information regarding their year of residency training, 13 (16.9%) were in their first year of residency training, 16 (20.8%) were in their second year of residency training, 16 (20.8%) were in their third year of residency training, and 32 (41.6%) were in their fourth year of residency training. Twenty-six radiology residents provided no response. Among the 68 participants who gave information regarding the duration of breast imaging training they had received, the duration of breast imaging training was one month in 25 radiology residents (36.8%), two months in 24 radiology residents (35.3%),

Table 1. The Proportion of Correct Answers According to Ultrasonographic BI-RADS Lexicon

Variable	Proportion of Correct Answers	*p*-Value
Orientation	93.1% (161/173)	< 0.001
Shape	91.3% (232/254)	
Margin	66.4% (263/396)	
Echo pattern	68.1% (233/342)	
Posterior features	94.3% (164/174)	

Data in parentheses are the number of correct answers/total number of answers.
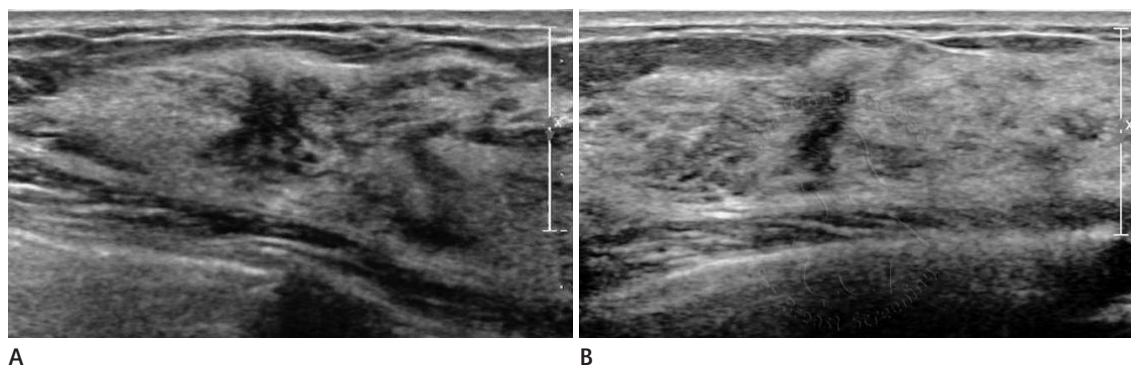BI-RADS = Breast Imaging Reporting and Data System

Fig. 1. Transverse **(A)** and longitudinal **(B)** ultrasonographic images showing an irregular hypoechoic mass with spiculated margins. The proportion of correct answers for margin was 74.1% (60/81). The mass was confirmed as a complex sclerosing lesion. Complex sclerosing adenosis can be seen as a spiculated margin.

Table 2. The Proportion of Correct Answers for Ultrasonographic BI–RADS Lexicon According to Year in Resident Training and the Duration of Training for Breast Imaging

	Number of Residents	Proportion of Correct Answers	*p*–Value
Year in resident training			0.167
1st	16	69.2% (119/172)	
2nd	16	76.0% (171/225)	
3rd	16	81.9% (186/227)	
4th	33	79.9% (373/467)	
Duration of training (months) for breast imaging			0.368
1	28	81.3% (273/336)	
2	24	77.4% (271/350)	
3–4	19	77.2% (203/263)	

Data in parentheses are the number of correct answers/total number of answers.
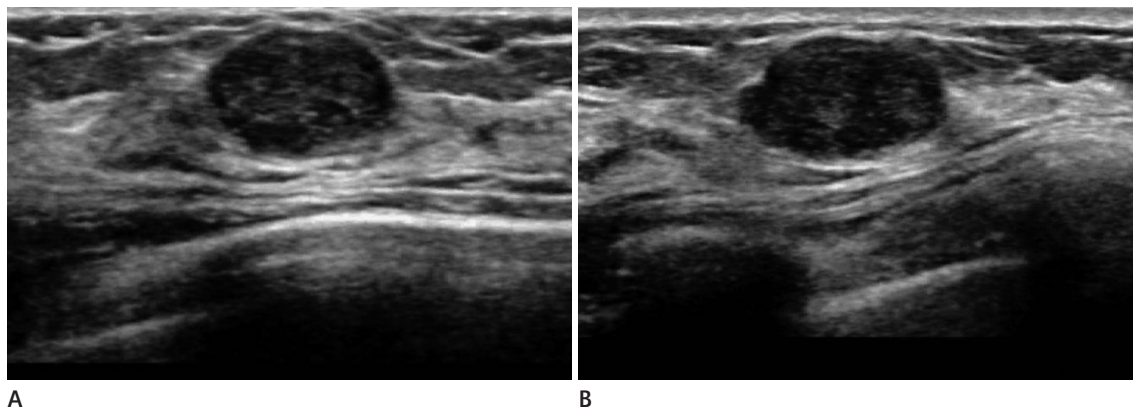BI-RADS = Breast Imaging Reporting and Data System

Fig. 2. Transverse **(A)** and longitudinal **(B)** ultrasonographic images of an oval circumscribed hypoechoic mass showing BI-RADS category 3. The proportion of correct answers for this BI-RADS category was 38.2% (26/68). The mass was confirmed to be a fibroadenoma.
BI-RADS = Breast Imaging Reporting and Data System

Table 3. The Proportion of Correct Answers According to BI–RADS Category

BI–RADS Category	Pathology	Proportion of Correct Answers
2	Intramammary lymph node	63.6% (42/66)
2	Lipoma	45.3% (24/53)
2	Involuting fibroadenoma	16.2% (12/74)
3	Fibroadenoma	38.2% (26/68)
4A	Intraductal papilloma	41.3% (31/75)
4B	Tubular carcinoma	18.8% (16/85)
4B	Complex sclerosing adenoma	7.5% (6/80)
4C and 5	Invasive ductal carcinoma	18.5% (15/81)
4C and 5	Ductal carcinoma *in situ*	26.7% (23/86)
4C and 5	Diabetes mastopathy	79.5% (62/78)
4C and 5	Invasive ductal carcinoma	87.5% (63/72)

Data in parentheses are the number of correct answers/total number of answers.
BI-RADS = Breast Imaging Reporting and Data System

and three-four months in 19 radiology residents (27.9%). Thirty-five radiology residents provided no response.

With respect to the US BI-RADS lexicon descriptors, the proportion of correct answers for shape, orientation, and posterior feature was significantly higher than that for margin and echo pattern ($p < 0.001$) (Table 1). Among the margin descriptors, the proportion of correct answers for circumscribed (88.0%), indistinct (82.4%) and spiculated (74.1%) (Fig. 1) margins was higher than that for microlobulated (51.8%) and angular (30.0%) margins. However, after dichotomizing the mass margin into 'circumscribed' or 'not circumscribed', the proportion of correct answers for 'not circumscribed' increased up to 97.4%. The proportion of correct answers for lexicon descriptors ranged from 69.2% to 81.9% according to the year of residency ($p = 0.167$) and from 77.2% to 81.3% according to the duration of breast imaging training ($p = 0.368$) (Table 2).

With respect to the BI-RADS category, the proportion of correct answers was 16.2–63.6% for category 2, 38.2% for category 3 (Fig. 2), 41.3% for category 4A, 7.5–18.8% for category 4B, and 18.5–87.5% for category 4C and 5 (Table 3). There was no significant difference in the proportion of correct answers according to the pathology (41.1% for benign vs. 36.3% for malignancy, $p = 0.176$) or the dichotomized BI-RADS category (39.9% for category 2 or 3 vs. 38.8% for category 4 or 5, $p = 0.813$). The proportion of correct answers for the BI-RADS category was 30.4% ($n = 28$ of 92) among the first-year radiology residents, 37.8% ($n = 59$ of 156) among the second-year radiology residents, 39.6% ($n = 55$ of 139) among the third-year radiology residents, and 42.9% ($n = 130$ of 303) among the fourth-year radiology residents, but there were no significant differences ($p = 0.186$) (Table 4). The proportion of correct answers for the BI-RADS category was 35.4% ($n = 76$ of 215) after one month of breast imaging training, 37.0% ($n = 87$ of 235) after two months of breast imaging training, and 47.8% ($n = 77$ of 161) after three-four months of breast imaging training ($p = 0.033$) (Table 5). The trend in each of the 3 categories was statistically significant ($p = 0.018$) (Table 5). Therefore, radiology residents' comprehension of the BI-RADS category on breast US had a tendency to improve according to the duration of training. Posthoc analysis of these results revealed a significant improvement in the proportion of correct answers when comparing the respondents with three-four months of training to those with one month of training (Bonferroni corrected p-value = 0.044) (Table 5). In comparison with radiology residents' performance after 1 month of training, radiology residents' performance after two months of training was improved although it was not statistically significant (Bonferroni corrected p-value = 0.096) (Table 5).

DISCUSSION

Although mammography is a very useful imaging modality for detecting and diagnosing breast cancer, its sensitivity for detecting breast cancers is reported to be as much as 50% lower in dense breasts (1-3). Therefore, supplemental US for the detection of breast cancer is being widely recommended in women with dense breasts (4-7). At this point, adequate training and experience in breast US are very important, particularly in areas where dense breasts are common, such as Asia. However, there is a lack of guidelines that indicate the adequate amount of breast imaging training radiology residents should receive.

To assess the training performance in breast US, we used BI-RADS descriptors or final assessment whose reliability for the prediction of malignancy has been validated and the interobserver agreement has been found to be good in previous studies (13-15). In this report, the proportion of correct answers given by radiology residents for margin and echo pattern on breast US was lower than that for the other descriptors (Table 1). We as-

Table 4. The Proportion of Correct Answers for BI-RADS Category According to Year in Resident Training

	Number of Residents	Proportion of Correct Answers	p-Value
Year in resident training			0.186
1st	16	30.4% (28/92)	
2nd	16	37.8% (59/156)	
3rd	16	39.6% (55/139)	
4th	33	42.9% (130/303)	

Data in parentheses are the number of correct answers/total number of answers.
BI-RADS = Breast Imaging Reporting and Data System

Table 5. The Proportion of Correct Answers for BI-RADS Category According to the Duration of Training for Breast Imaging

Duration of Training (Months)	Number of Residents	Proportion of Correct Answers	p-Value				
			Among 3 Group	Test for Trend	vs. 1	vs. 2	vs. 3–4
1	28	35.4% (76/215)	0.033	0.018		0.032	0.015
						0.096*	0.044*
2	24	37.0% (87/235)			0.032		0.712
					0.096*		> 0.999*
3–4	19	47.8% (77/161)			0.015	0.712	
					0.044*	> 0.999*	

Data in parentheses are the number of correct answers/total number of answers.
*Bonferroni corrected p-value.
BI-RADS = Breast Imaging Reporting and Data System

sumed that this is because margin and echo pattern are commonly mixed with one or more descriptors and it might also result in a lower value of interobserver agreement. In previous reports that evaluated interobserver variability between breast imaging radiologists, the interobserver agreement was fair for mass margin (kappa value: 0.32–0.4) and echo pattern (kappa value: 0.29–0.37), while the interobserver agreement for shape, orientation and posterior acoustic features was substantial or moderate (14, 16, 17). However, in one previous study, the interobserver agreement for margin when simplified to 'circumscribed' or 'not circumscribed' was improved to moderate (17), which was also consistent with our results since the proportion of correct answers when it was dichotomized into these two categories was greater than 90%. Because one of the four descriptors of 'not circumscribed' margin should be considered as suspicious findings, variability in the selection among 'not circumscribed' descriptors may not have a serious clinical impact. Biopsy is the optimal management for category 4 or higher breast lesions, and this may lessen the importance of variability among observers regarding the margin descriptors. Our results showed that the proportion of correct answers for indistinct or spiculated margins (82.4% and 74.1%, respectively) was higher than that for other margin descriptors (30–51.8%), which is consistent with previous results (17).

According to the year of resident training, the proportion of correct answers for lexicon descriptors and BI-RADS category increased with every year of training, but there was no significant difference among the years of training (p = 0.167 and 0.186, respectively) (Tables 2, 4). This finding is consistent with a previous domestic report using mammography which indicated that the year of training alone does not affect residents' performance (18). We suppose that this is because the training schedule at each institution is very different for each year of residency and breast imaging training is mostly performed in dedicated breast imaging sections, and it does not overlap with the other subspecialties of the radiology department.

In the present study, the proportion of correct answers for the BI-RADS category increased with an increasing duration of training from one month to three-four months with a significant improvement in the proportion of correct answers from one month to three-four months of training despite the lack of a significant difference in terms of lexicon descriptors. These findings are

consistent with a previous report on mammographic training, which showed that radiology residents' performance in mammographic interpretation was correlated with the training period (p < 0.001) (18). The three-four month duration of training is identical to the period of formal training required by a physician to interpret mammograms independently (19). According to our results, three-four months of training will also improve radiology residents' performance in interpretation of breast US. But, there was no significant improvement between two and three-four months of training. We assumed that these results might be associated with each institution's quality of education. However, we did not investigate each institution's quality of education. Although post-hoc analysis did not show significant improvement between two and three-four months of training, radiology residents' comprehension of the BI-RADS category on breast US had a tendency to improve according to the duration of training. In our opinion, three-four months of training is ideal for improving radiology residents' performance in interpretation of breast US, but 2 months of training would be acceptable as the minimal duration of breast US training. In our study, the duration of breast imaging training was one or two months in 72.1% of the participants who answered the question on the duration of breast imaging training.

This study has some limitations. The first limitation is the large amount of missing data. Second, mammographic information was not available during the survey; therefore, descriptors of calcifications were inevitably excluded. Mammography is quite helpful for evaluating breast lesions, especially in cases of calcification. However, this study aimed to evaluate the comprehension of radiology residents in breast US. Third, we did not include questions about elasticity or color Doppler image which has been added to the fifth edition of BI-RADS because the likelihood of malignancy based on these descriptors is controversial. Finally, we did not consider the differences in training quality, the number of breast US examinations performed per person during training, whether other subspecialties overlapped during breast imaging training and the time interval between the last training and the survey.

Radiology residents' performances in breast US interpretation and comprehension of BI-RADS descriptors and final assessments were variable. Comprehension of US BI-RADS categories and descriptors were not associated with the year of resident training, but they were improved with the duration of breast im-

aging training. Based on our findings, radiology residents' assessment of the BI-RADS category was significantly improved with three-four months of training compared with one month of training and these results might be helpful in deciding the optimal duration of radiology residents' training.

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Breast Imaging Reporting and Data System에 대한 영상의학과 전공의들의 이해도: 초음파 검사 표준용어 및 최종평가분류

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목적: 영상의학과 전공의들의 Breast Imaging Reporting and Data System (이하 BI-RADS) 초음파 검사 표준용어 및 최종평가분류에 대한 이해도를 분석하고 적절한 유방초음파 수련기간을 제시하고자 하였다.

대상과 방법: 102명의 영상의학과 전공의들을 대상으로 하였다. 초음파 검사 표준용어에 관련한 질문 16개, 최종평가분류에 관련한 질문 11개가 주어졌다. 이들의 답을 연차 및 수련기간에 따라 분석하였다.

결과: 수련기간에 따른 분석에서 표준용어에 대한 정답률은 77.2%에서 81.3%로 기간에 따른 차이가 없었으나($p = 0.368$), 최종평가분류에 대한 정답률은 3~4개월간 수련받은 그룹에서 1개월간 수련받은 그룹보다 의미 있게 높았다($p = 0.033$). 연차에 따른 분석에서는 표준용어와 최종평가분류에서 모두 의미 있는 차이를 보이지 않았다.

결론: 전공의들의 BI-RADS 초음파 검사 표준용어 및 최종평가분류에 대한 이해도는 연차에 따라 의미 있는 차이가 없었다. 최종평가분류에 대한 이해도는 1개월과 비교하여, 3~4개월간 수련을 받은 경우 의미 있게 향상되었다.

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