3D Automated Breast Ultrasound System: Comparison of Interpretation Time of Senior Versus Junior Radiologist

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ABSTRACT

Objective: This study aimed to compare the automated breast ultrasound system (ABUS) reading time of breast radiologist to a radiology resident independent of the clinical outcomes.

Materials and Methods: One hundred women who underwent screening ABUS between July and August 2017 were reviewed retrospectively. Each study was examined sequentially by a breast radiologist who has more than 20 years of experience in breast radiology and third year resident who has 6 months of experience in breast radiology. Data were analyzed with Spearman' correlation, Wilcoxon Signed Ranks Test and Kruskal-Wallis Test and was recorded.

Results: The mean age of patients was 42.02±11.423 years (age range16-66). The average time for senior radiologist was 223.36±84.334 seconds (min 118 max 500 seconds). The average time for junior radiologist was 269.48±82.895 seconds (min 150 max 628 seconds). There was a significant difference between the mean time of two radiologists (p=0.00001). There was a significant difference regarding the decrease in the reading time throughout study with the increase of number of cases read by the breast radiologist (p<0.05); but not with the resident radiologist (p=0.687). There was a correlation between BI-RADS category and reading time for both the breast radiologist and the resident (p=0.002, p=0.00043 respectively) indicating that patients who had findings caused longer reading times.

Conclusion: ABUS reading time may differ according to the experience of the user, however the times of an experienced and non-experienced user is comparable.

Keywords: Automated breast ultrasound, breast ultrasonography, breast cancer, interpretation time of ABUS, average time of ABUS

Introduction

Mammography is the gold standard for breast cancer screening yielding 30% reduction in breast cancer mortality among women aged 50-74 years (1). Mammographic sensitivity for breast cancer decreases significantly with increasing breast density. To overcome this, ultrasonography (US) has been studied as an adjunct to mammography in dense breasts and studies showed significant increase in detection of small cancers when added to mammography (2, 3).

Hand Held Ultrasound (HHUS) is widely available and a well-tolerated method which allows detailed evaluation of the breast and the axilla and has the availability of color Doppler and elastography modes (4, 5). On the other hand, HHUS has several disadvantages. It is time consuming, operator-dependent, not reproducible and requires high level of skill and experience. It has high false positivity rate, lacks standardized techniques, allows only two-dimensional (2D) imaging with a small field of view (FOV) (4, 6-8).

Automated three-dimensional (3D) breast ultrasound (ABUS) was developed to obtain an operator independent system. It is reproducible and obtains three dimensional (3D) high resolution imaging with a large FOV. ABUS is reported as a comfortable and time-efficient technique (7-10). Multiple studies have demonstrated similar sensitivity, cancer detection rate, diagnostic accuracy rates and image quality for both ABUS and HHUS (11-16). The new generation ABUS provides better detection of architectural distortions, lesion localization and typical hyperechoic rim on coronal planes (9, 17, 18). Thick hyperechoic rim is suspicious sonographic finding which suggests

the presence of invasive cancer. However, ABUS has some limitations such as 10% lower cancer detection rate, higher false positive results and recalls, shadowing artefacts, incompatibility for US guided biopsy, limited evaluation of axilla, absence of elastography or Doppler techniques for further characterization of the lesions and relatively higher cost compared to HHUS (4, 18-20).

To our knowledge, limited studies of reading time of US have been reported in the English literature (4, 21-23). The average total time to complete a HHUS is 19 minutes (23). The aim of this study was to assess ABUS reading time and compare the reading times of a breast radiologist and a radiology resident independent of the clinical outcomes.

Materials and Methods

Institutional review board approval (No: 2018-2/9) was obtained for this study by Acıbadem Mehmet Ali Aydınlar University ethics committee. Additional informed consent was obtained from all patients for which identifying information is included in this article. One hundred women (age range 18-66 years; mean 42.02±11.423 years) who underwent screening ABUS examination between July and August 2017 were reviewed retrospectively.

We excluded twelve patients who were already diagnosed with breast cancer and had a breast surgery history, skin disorders, inflammatory conditions of the breast, breastfeeding woman and pregnancy. Patients with larger breasts which needed more than three positions were also excluded from the study. ABUS images of one hundred women were evaluated by two readers.

Automated Three-Dimensional (3D) Breast Ultrasound (ABUS)
Automated breast ultrasound studies were performed using the ABUS (Invenia™ ABUS, GE Healthcare) scanner by two well-trained radiology technicians with one month of experience on automatic ultrasound. The examination was performed in the supine position with the ipsilateral arm above the head. A hypoallergenic lotion and a disposable membrane were used to aid an acoustic coupling. Each breast was examined in three different positions; i) anteroposterior (AP), ii) lateral (LAT) including the pectoral muscle and iii) medial (MED). A nipple marker was placed on the coronal view to locate the nipple position for accurate location in each position.

Automated breast ultrasound system acquires 15.4 cm x17.0 cm area with the volume from the skin to the chest wall up to 5 cm deep. The frequency of transducer varied between 6-15 MHz.

Each study included bilateral anteroposterior, medial, and upper-outer quadrant positions.

For the lateral position, the breast tissue was pushed from axilla towards the sternum and covered the upper outer breast. For the medial position, the breast tissue was pushed from sternum toward the axilla, covering the inner inferior part of the breast. Minor compression was performed to the breast to avoid breast movement and obtain better view of the volume.

All positions included the nipple as a landmark. The scanning time for the sweeping of the probe the whole volume of interest was one minute per view.

Data were sent from the ABUS to the dedicated workstation. Multiplanar compounded images in three planes (coronal, sagittal and axial reconstructions) were reviewed.

Data Evaluation
Each study was examined sequentially by a breast radiologist who has more than 20 years of experience in breast radiology, three months of experience in ABUS reading prior to the study (senior radiologist) and third year resident (junior radiologist) who has 6 months of experience in breast radiology, one-month experience in ABUS reading prior to the study blinded to each other's results. Junior radiologist had a training for ABUS for one month prior to the study. Two radiologists participated in ABUS training via online webinars. A standard review protocol was used by both readers, which included, evaluation of coronal and transverse planes of each volume. Each plane was evaluated in the same order. The cases were evaluated in the same sequence. The reading environment was same.

Patient's age, reading time of 2 radiologists and American College of Radiology Breast Imaging Reporting and Data System (BIRADS) Atlas category for each patient were noted. The results were classified as: BIRADS 0 (incomplete), BIRADS 1 (negative), BIRADS 2 (benign findings).

Statistical Analysis
Data were analyzed with Statistical Package for the Social Sciences version 24.0 (IBM Corp.; Armonk, NY, USA). Spearman' correlation, Wilcoxon Signed Ranks Test and Kruskal-Wallis Test were recorded. P value <0.05 was considered for statistical significance for all tests. Wilcoxon Signed Ranks Test was used for significant difference between the mean time of two radiologists. Spearman' correlation was used for significant difference regarding the decrease in the reading time throughout study with the increase of number of cases read by the breast radiologist. Kruskal-Wallis Test and Spearman' correlation were used for correlation between BI-RADS category and reading time for both the breast.

Results

The average time for evaluating the ABUS data for the senior radiologist was 223.36±84.334 seconds (min 118 max 500 seconds). The average time for junior radiologist was 269.48±82.895 seconds (min 150 max 628 seconds) as detailed on Table 1. There was a significant difference between the mean time of two radiologists (p=0.00001). There was a significant difference regarding the decrease in the interpretation time throughout study with the increase of number of cases read by the breast radiologist (p<0.05); but not with the resident radiologist (p=0.687) (Figure 1). The reading time of the breast radiologist decreased throughout the study (Figure 2).

Table 1. The average time for evaluating the ABUS data for the senior and junior radiologist

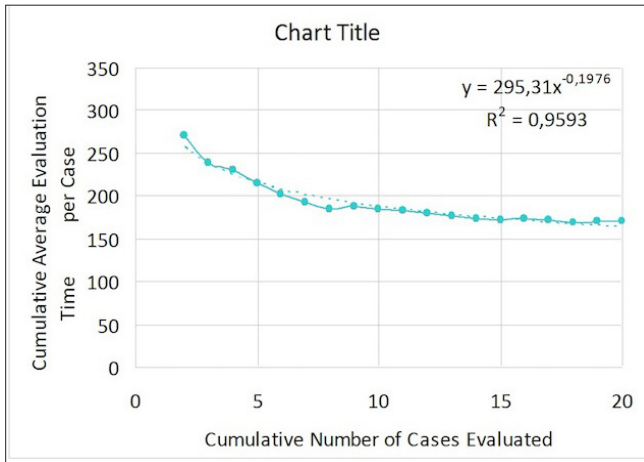| Descriptive Statistics	Minimum	Maximum	Mean	Std. Deviation
Age	16	66	42.02	11.423
Senior radiologist (seconds)	118	500	223.36	84.334
Junior radiologist (seconds)	150	628	269.48	82.895
Average time (seconds)	139.5	458.5	246.424	67.0528

Figure 1. The reading time of the senior breast radiologist decreased throughout the study
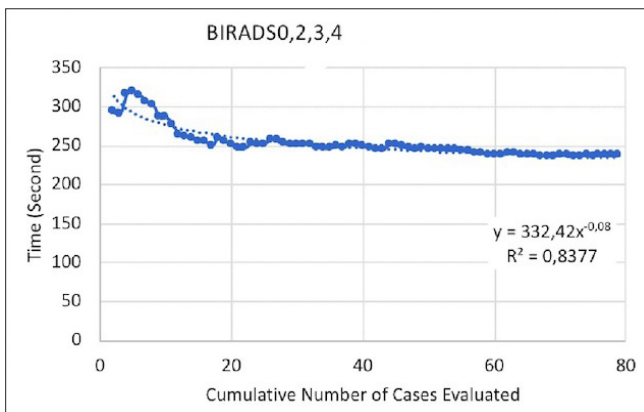

Figure 2. Learning curve of breast radiologist

We classified cases according to American College of Radiology BIRADS Atlas category; including BI-RADS category I in 20 patients (20%), BI-RADS category II in 65 patients (65%), BI-RADS category 0 in 15 patients (15%). All BI-RADS category 0 patients were examined with second look HHUS. Two of these changed to BI-RADS 2, seven to BI-RADS 3 and six to BI-RADS 4. One of six BI-RADS 4 cases proved to be an invasive carcinoma with a diameter of 6 mm which was detected by both readers. There was a correlation between BI-RADS category and reading time for both the breast radiologists and the resident (p=0.002, p=0.00043 respectively) indicating that patients who had findings resulted with longer reading times (Table 2). This finding was evident for the resident compared to the findings of the breast radiologist taking the BIRADS category into consideration.

Discussion and Conclusion

This study highlights the interpretation time of 3D ABUS by two radiologists with different experiences. Junior radiologist showed to be inferior to senior radiologist, particularly in the average time and learning curve. Our study showed that inexperienced radiologist's learning curve and the reading time is longer, however the mean time difference is 46 seconds.

Average time for 2 radiologists in 100 cases was 246.424±67.0528 (min 139.5, max 458.5) seconds. We observed that ABUS reading is fast and shortens during the time span of learning curve. This interpreta-

Table 2. Kruskal Wallis Test, correlation between BI-RADS category and reading time

Ranks		
BIRADS N		**Mean Rank**
Reding Time for Breast Radiologist	0	66.50
	1	27.48
	2	54.27
	3	56.64
	4	64.57
Reading Time for Breast Radiologist	0	62.75
	1	36.00
	2	47.59
	3	74.07
	4	84.00
Mean Time (second)	0	65.25
	1	28.05
	2	50.89
	3	69.64
	4	80.71

tion time is agreeable when compared to hand-held bilateral screening ultrasound examination which is reported to take an approximately 19 min (23) particularly in practices where the radiologist performs. We believe that ABUS can be a good alternative as a less time-consuming examination for a radiologist in breast screening programs particularly in centers with high patient flow.

We observed a significant reading time difference between BI-RADS 1 and other BIRADS categories (BI-RADS 0,2). It would take less time to read a completely normal exam (BIRADS 1) than an abnormal exam (BIRADS 0 and 2).

Automated breast ultrasound is more promising for breast screening purposes where majority of women are BI-RADS category 1. Thus, recall is needed for category 0 lesions which will be higher in diagnostic studies but will be low in screening. Many studies have documented that the ABUS technique is independent of an operator, has standardized views, is faster to acquire images. ABUS requires less training than HHUS. Total examination time is about 10-15 minutes by a trained sonographer (7, 8, 24-27). The interpretation time of ABUS varies between 2,9 and 9 minutes (24-26). The reason of this variability may be the differences in experiences, presence of abnormalities, and to the filled reports or protocols (25, 26). Our study showed that readers with different experiences can perform interpretation of the images in comparable durations. However, a recent study demonstrated an average ABUS interpretation time of less than 3 minutes with 3 different experienced readers. Their study included patients with ACR BI-RADS 4 breast density classifications of C or D which in line with our findings (28).

To assess or compare radiologists' performance in the detection of breast cancer with 3D ABUS were not part of this study. However, in another related study, the addition of ABUS to screening mammog-

raphy has been found to increase in cancer detection in line with our findings (29).

Our study has several limitations: First, the number of study participants was relatively limited. Second, it would have been more objective to compare reading time with varied experienced more than 2 radiologists. A multicenter study with several readers may help to show the variability of reading times. Third, this study was a retrospective study and the clinical outcome was not included in the analysis.

In conclusion, ABUS reading time may differ according to the experience of the user; however, the times of an experienced and non-experienced users are comparable.

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