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Automated breast ultrasound (ABUS) as a screening tool: initial experience

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Abstract

Background: Breast cancer is a major health problem, being the most common cancer in women. Early detection of breast cancer aims to the reduction of mortality and morbidity rates. Conventional screening methods include mammography and ultrasonography; however, both modalities have their limitations. Automated breast ultrasound (ABUS) is a recent technological advancement in the field of breast imaging having the benefit of standardization of the scans and lack of operator dependence as in conventional handheld ultrasound scans. The aim of this work was to report our initial experience of the added value of ABUS as a breast screening tool. The study included 200 patients who had screening mammograms, ultrasound, and ABUS.

Background:

Background :

- Breast cancer is the most common cancer in women; account for 22.9% of female cancer worldwide and 29.1% of cancer-related death.

- Early detection of breast cancer reduce morbidity and mortalities rate.

- Mammography establish as imaging modality for screening breast cancer. However it relative low sensitivity and specificity especially in dense breast due to low contrast between density of tumor tissue and surrounding tissue.

- Breast ultrasound + mammography proven improve tumor detection rate, especially in women with dense breast (ACR C & D).

- Conventional breast ultrasound is operator dependent and result affected by operator skill and experience

- Automated Breast Ultrasound (ABUS) is develop to overcome issue of operator dependence of conventional ultrasound scanning by standardize image acquire.

- It produce volumetric acquisition of multiple US image of breast that can be store and post-processed i.e. 3D and multiplanar reformatting

- ABUS has been around for more than a decade with earlier system provide inadequate image quality for proper interpretation.

- Recent development of high-frequency transducer allow a reproduction of image with superior qualities in short time.

Patient and Method:

Prospective study:

Objective:

1. To add vault of ABUS in screening women with suspected breast mass compare to conventional mammography and hand held ultrasound.

- Inclusion criteria:
  1. Women in childbearing age complain of breast pain and lump.
  2. Women positive family history of Breast cancer.

- Exclusion criteria:
  1. Patient with known diagnosis of breast cancer under treatment.
  2. Patient with hx of mastectomy or previous intervention for breast lesion.

Technique:

- Total 200 patient include in the study with all patient subject to full clinical examination, 80 patient had biopsy and histopathological analyzed base on imaging findings.

- Routine screening Mammography using Craniocaudal (CC)and mediolateral oblique (MLO) view perform in patient age above 30
  - ❖ Total 108 patient undergone mammogram study.

- Patient age below 30 were screen by ultrasound only.

All patient had conventional breast ultrasound examination and ABUS for both breast.

Conventional Breast ultrasound

- Tranducer: 7-11 Hz linear transducer.

- Patient lying supine and her ipsilateral hand raised above the head.

- Radial scanning technique in a clockwise fashion, using nipple as center point

- Scanning of each breast quadrant in sagittal and transverse plane
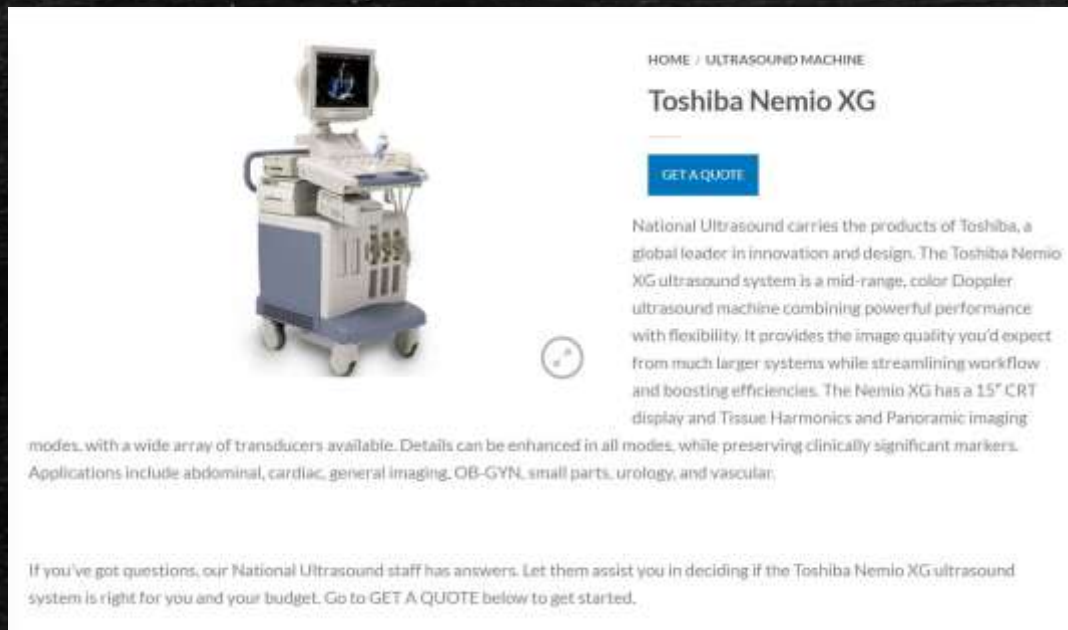
- Examination time : about 20 min.

Automated breast ultrasound (ABUS)

- Transducer: 14 Hz linear transducer.

- Supine with wedge on the back of examination site.

- Adequate coupling gel applied with extra amount applied to nipple –areolar region.

- Transducer applied to breast using mild compression (to avoid motion artifact).

- Scanning perform in 3 view(coronal, sagittal and transverse view)

- Using nipple as centering point,. AP position first taken.

- Lateral position taken by angling the probe from axilla toward sternum;

- Medial position angle from sternum to axilla

- Scan initially review on machine monitor for qualities reassurance.

- Volumetric data transfer to ABUS workstation for post processing and analysis.

- Scanning time for each acquisition time : 1 minutes; entire examination time 15 min.

Machine use

Conventional ultrasound

- Toshiba Nemio XG Ultrasound machine (Toshiba Medical Systems, Japan)

ABUS

- Invenia ABUS machine (GE Healthcare, USA)

More on ABUS

Statistical analysis

- Descriptive statistic used.

- Analytic statistic using t-test and chi-square tests use to compare clinical and imaging findings.

- Obtained pathological diagnosis as gold standard of detected mass.

Result:

Age: 19-61 (mean 35.44; SD 10.83)

Most common complain was breast pain: 140 pts(70% of patient population)

32 patients with breast lump (16 %)

108 patients undergone mammography

Total 76 patient (70.8%) with dense breast ACR C (28 pt) and D (48 pt)

In 200 patients, 120 negative imaging and pathological findings.

80 patients with different breast pathology

48 benign (most common fibroadenoma in 36 patient)

32 malignant (most common invasive ductal Carcinoma in 22 patient

50 patient with single lesion; 30 with multiple lesion (20 show lesion in both breast).

Comparison ABUS with Conventional US

ABUS

Conventional ultrasound

- Detect 76 out of 80 lesions

- Detected 66 out of 80 lesions

Table 1 The comparison between ABUS and HHUS in lesion detection as regards the number of patients. t test was used to compare in between with p value < 0.05 considered significant

	ABUS	HHUS		p
Lesions detected	76/80	66/80	*	0.012
Accuracy	98.0%	93.0%		0.016
Sensitivity	95.0%	82.5		0.012
Specificity	100.0%	100.0%		—
PPV	100.0%	100.0%		—
NPV	96.8%	89.6		0.023
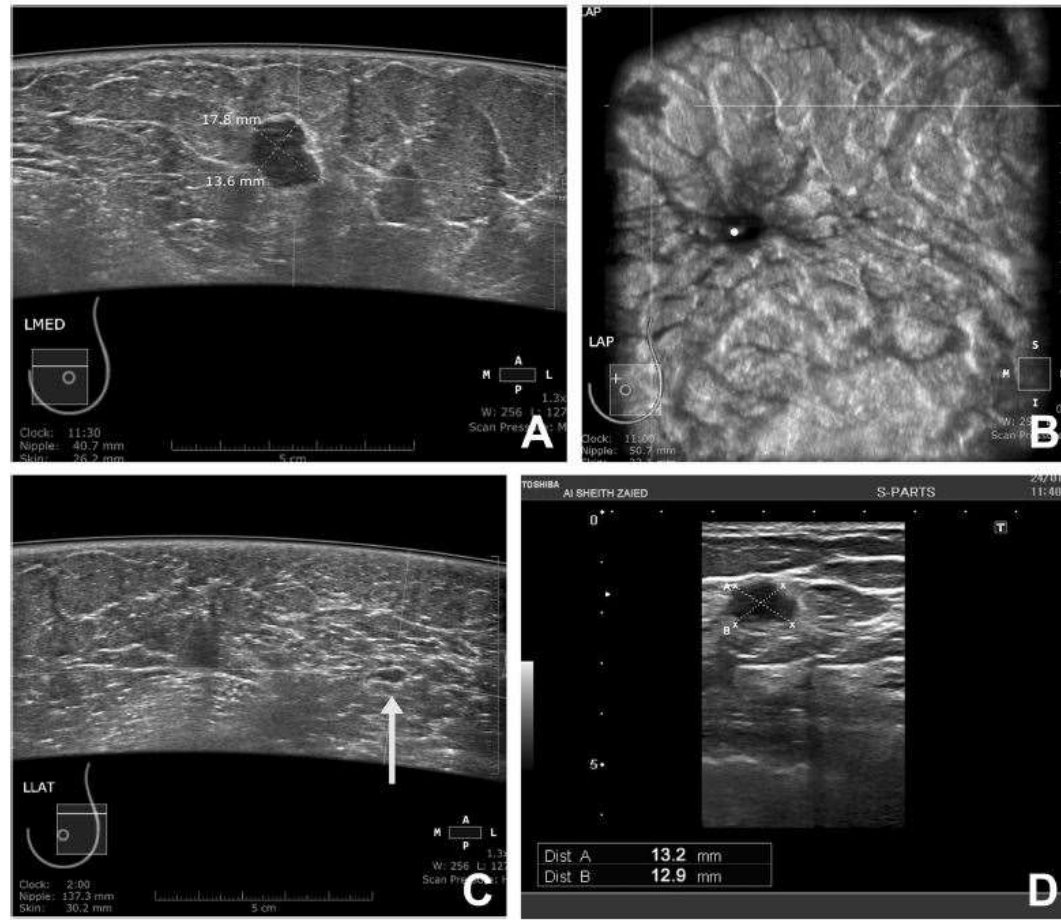
Fig. 1 Female patient 26 years old with histopathological diagnosis of an invasive ductal carcinoma type II. **a, b** Axial and coronal reformatted ABUS images shows a well-defined hypoechoic mass showing irregular outline in the left breast at its upper inner quadrant. The lesion measured 13.6 × 17.8 mm. **c** Axial reformatted ABUS image showing another well-defined smaller hypoechoic lesion in the upper outer quadrant (arrow) of the left breast, which was not seen by conventional HHUS. The smaller lesion measured 3 × 4 mm. **d** Corresponding HHUS of the larger left breast mass lesion, the lesion is well-defined, hypoechoic, having lobulated outlines and measuring 13.2 × 12.9 mm. The lesion was graded as BIRADS IV
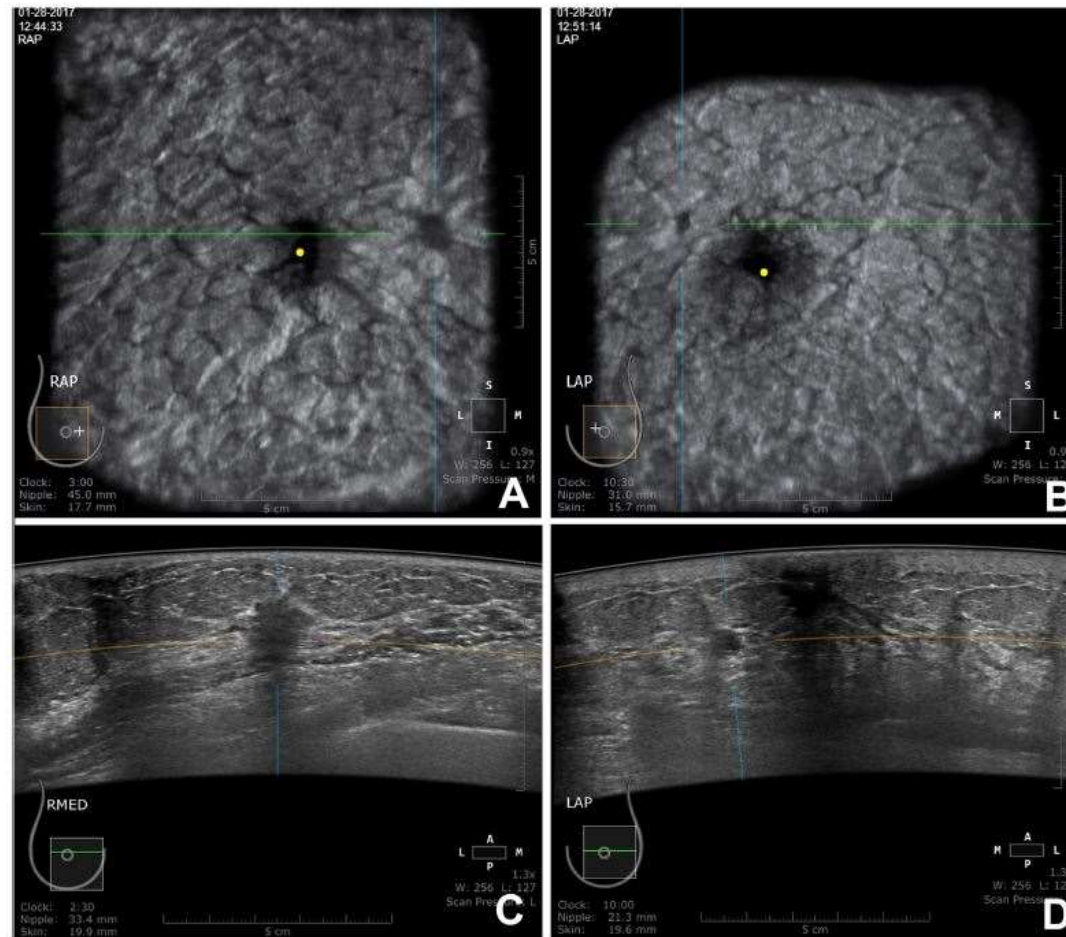
Fig. 2 Female patient 24 years old with histopathological diagnosis of an invasive ductal carcinoma type II. **a** Coronal reformatted ABUS images of the right breast showing a well-defined hypoechoic lesion in its upper inner quadrant. **b** Coronal reformatted ABUS images of the left breast showing a smaller well defined hypoechoic lesion in its upper inner quadrant. **c** Axial ABUS image of the lesion in the right breast showing a well-defined hypoechoiec lesion showing irregularity of its border with posterior acoustic shadowing the lesion was graded as a BI-RADS IV lesion. **d** Axial ABUS image of the lesion in the left breast showing a small rounded hypoechoiec lesion with well-defined border and regular outlines. This lesion was missed on HHUS

Compare using mammography alone with addition of ABUS to mammography

Mammograph alone

- Lesion detected in 24 out of 40 patient with positive findings.

ABUS + mammography

- Lesion detected in 38 out of 40 patient with positive findings.

Table 2 The comparison between the numbers of patients with lesion detected by mammography alone and with the addition of ABUS. t test was used to compare in between with p value < 0.05 considered significant

	Mammography	Mammography + ABUS	p
Lesions detected	24/40	38/40	*0.001
Accuracy	85.19%	98.15%	0.0005
Sensitivity	60%	95%	0.012
Specificity	100.0%	100.0%	—
PPV	100.0%	100.0%	—
NPV	80.95%	97.14%	0.023

Added value in ABUS to mammography:
Detection of lesion in breast densities ACR C and D

Mammography

- 20 out of 36 lesions

Mammography + ABUS

- 34 out of 36 lesions

Table 3 Comparison between ABUS and mammography in the detection of lesions in patients with dense breasts ACR C and ACR D. t test was used to compare between the results with p value < 0.05 considered significant

ACR breast density	Number of lesions detected	Lesions detected by mammography alone	Lesions detected by mammography + ABUS	p value
C (dense)	8	4	6	0.13
D (extremely dense)	28	16	28	0.0005
C and D	36	20	34	* 0.0001
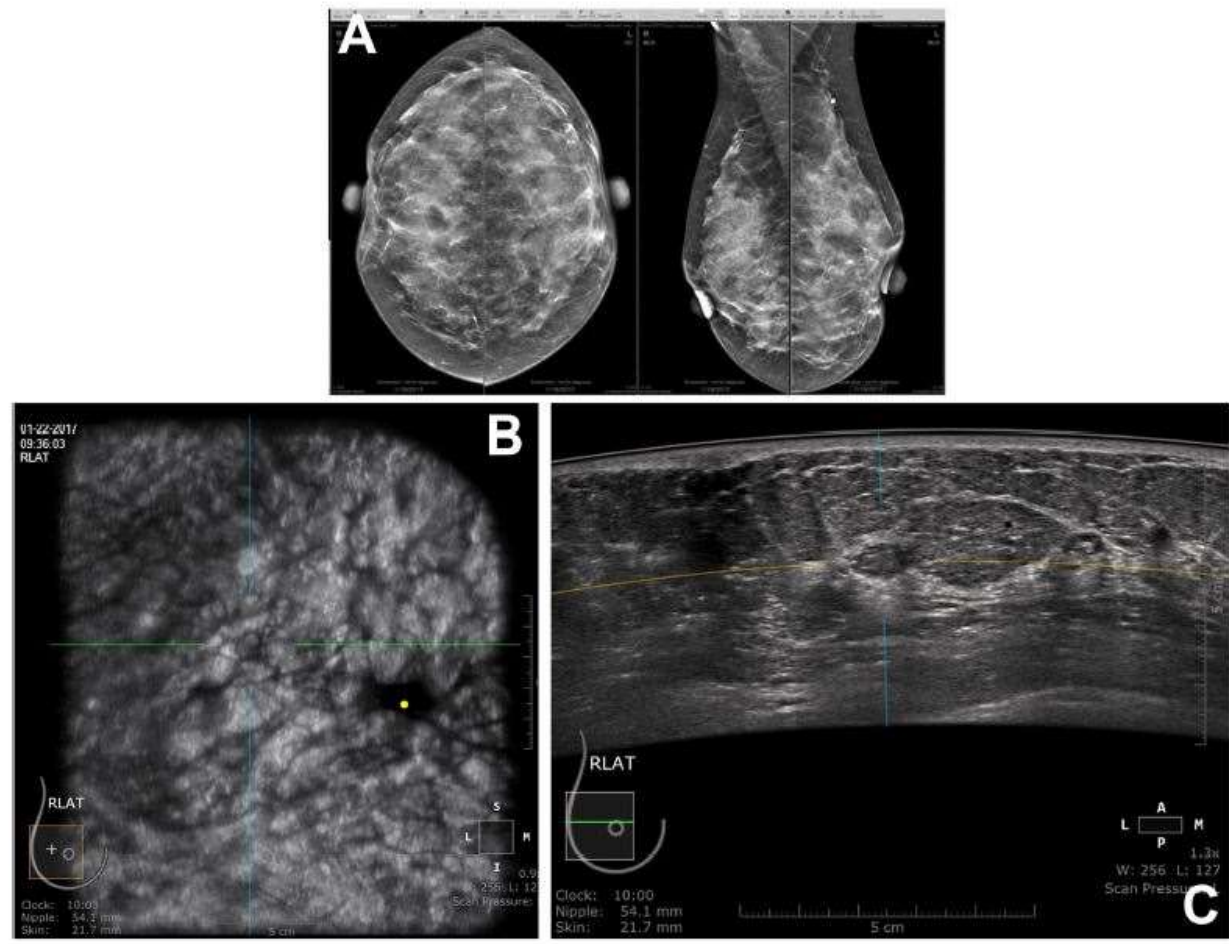
Fig. 3 Female patient 31 years old with histopathological diagnosis of fibroadenoma. **a** Mammogram (cranio-caudal and mediolateral oblique views of both breasts) showing dense breast (ACR D) with no obvious lesions or calcifications. **b** Coronal reformatted ABUS image showing a small hypoechoic lesion in the upper outer quadrant of the right breast. **c** Axial reformatted ABUS image showing the small well-defined hypoechoic lesion which had a fine lobulated outline. The lesion was graded BI-RADS III

In detection of lesion < 5mm

ABUS

- 10 lesions detected

Conventional US

- 4 lesions detected.

p value of 0.002

Discussion:

▪ Ultimate goal of successful mammographic screening program is early detection of breast cancer.

▪ ABUS consider recent addition in breast screening tool intend to over come some limitation of conventional ultrasound screening.

▪ This study show significant increase in number of case with lesion detected by ABUS compare to conventional US with

1. increase accuracy 98% compare to 93%,
2. sensitivity 95 % compare to 82 %
3. 100% sensitivity and negative predictive value 96.8% compare to 89.6%

▪ These finding in agreement with those reported by choi et al.

– DOI: 10.7314/apjcp.2014.15.21.9101

Comparison of Automated Breast Volume Scanning and Hand- Held Ultrasound in the Detection of Breast Cancer: An Analysis of 5,566 Patient Evaluations

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Affiliations + expand

Abstract

Background: The purpose of this study was to compare the accuracy and effectiveness of automated breast volume scanning (ABVS) and hand-held ultrasound (HHUS) in the detection of breast cancer in a large population group with a long-term follow-up, and to investigate whether different ultrasound systems may influence the estimation of cancer detection.

Materials and methods: Institutional review board approval was obtained for this retrospective study, and informed consent was waived. From September 2010 to August 2011, a total of 1,866 ABVS and 3,700 HHUS participants, who underwent these procedures at our institute, were included in this study. Cancers occurring during the study and subsequent follow-up were evaluated. The reference standard was a combination of histology and follow-up imaging ($\geq$12 months). The recall rate, cancer detection yield, diagnostic accuracy, sensitivity, specificity, and positive (PPV) and negative (NPV) predictive values were calculated with exact 95% confidence intervals.

Results: The recall rate was 2.57 per 1,000 (48/1,866) for ABVS and 3.57 per 1,000 (132/3,700) for HHUS, with ? significant difference (p=0.048). The cancer detection yield was 3.8 per 1,000 for ABVS and 2.7 per 1,000 for HHUS. The diagnostic accuracy was 97.7% for ABVS and 96.5% for HHUS with statistical significance (p=0.018). The specificity of ABVS and HHUS were 97.8%, 96.7%, respectively (p=0.022).

Conclusions: ABVS shows a comparable diagnostic performance to HHUS. ABVS is an effective supplemental tool for mammography in breast cancer detection in a large population.

- Vourtsis et al reported that ABUS was comparable to conventional ultrasound is lesion comparison,

- It is outperformed conventional US in detection architextural distortion .

The Performance of 3D ABUS Versus HHUS in the Visualisation and BI-RADS Characterisation of Breast Lesions in a Large Cohort of 1,886 Women

Athina Vourtsis [1], Aspasia Kachulis [2]

Affiliations + expand

Abstract

Objectives: This study aimed to evaluate automated breast ultrasound (ABUS) compared to hand-held traditional ultrasound (HHUS) in the visualisation and BIRADS characterisation of breast lesions.

Materials and methods: From January 2016 to January 2017, 1,886 women with breast density category C or D (aged 48.6±10.8 years) were recruited. All participants underwent ABUS and HHUS examination; a subcohort of 1,665 women also underwent a mammography.

Results: The overall agreement between HHUS and ABUS was 99.8 %; kappa=0.994, p<0.0001. Two cases were graded as BI-RADS 1 in HHUS, but were graded as BIRADS 4 in ABUS; biopsy revealed a radial scar. Three carcinomas were graded as BI-RADS 2 in mammography but BI-RADS 4 in ABUS; two additional carcinomas were graded as BI-RADS 2 in mammography but BI-RADS 5 in ABUS. Two carcinomas, appearing as a well-circumscribed mass or developing asymmetry in mammography, were graded as BI-RADS 4 in mammography but BI-RADS 5 in ABUS.

Conclusions: ABUS could be successfully used in the visualisation and characterisation of breast lesions. ABUS seemed to outperform HHUS in the detection of architectural distortion on the coronal plane and can supplement mammography in the detection of non-calcified carcinomas in women with dense breasts.

Key points: • The new generation of ABUS yields comparable results to HHUS. • ABUS seems superior to HHUS in detecting architectural distortions. • In dense breasts, supplemental ABUS to mammography detects additional cancers.

Keywords: Automated breast ultrasound system; Breast cancer; Breast density; Breast ultrasonography; Digital mammography.

Vourtsis, A., Kachulis, A. The performance of 3D ABUS versus HHUS in the visualisation and BI-RADS characterisation of breast lesions in a large cohort of 1,886 women. *Eur Radiol* **28,** 592–601 (2018). https://doi.org/10.1007/s00330-017-5011-9

- Significant increase number of case with lesion detected by addition of ABUS to mammography and the use of mammography along found in this study.
  – 38 out of 40 compare to 24 out of 40 with p value < 0.001
  – The previous findings were most evidence in 36 patient with dense breast (ACR C and D) where lesion is detected in 20 patients by the use of mammography alone; 34 patients detected with the addition of ABUS
  – Sensitivity of lesion detection by mammography alone : 60 % and 95 % when ABUS combine with mammography.
  – Increase sensitivity of cancer detection by 36 % using ABUS with mammography as reported by Wliczek et al. and Kelly et al.
  – Statistically significant increase detection of lesion smaller than 5mm by ABUS when compare to conventional US (in agreement with Kelly et al who reported significant increase in the number of detected small invasive cancer measure less than 20,,wjem addomg ABUS to mammography.

Adding 3D Automated Breast Ultrasound to Mammography Screening in Women With Heterogeneously and Extremely Dense Breasts: Report From a Hospital-Based, High-Volume, Single-Center Breast Cancer Screening Program

Brigitte Wilczek [1], Henryk E Wilczek [2], Lawrence Rasouliyan [3], Karin Leifland [4]

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Abstract

Purpose: The aim of this study was to evaluate the impact of the 3D automated breast ultrasound (3D ABUS) when added to full field digital screening mammography (FFDSM), on breast cancer detection and recall rates in asymptomatic women with dense breasts examined in a high-volume breast cancer screening mammography center.

Methods and material: 1668 asymptomatic women, age 40-74 years, with heterogeneously dense parenchyma (ACR3) or extremely dense breast (ACR4) were included in the study. FFDSM was performed using standard craniocaudal (CC) and mediolateral oblique (MLO) views followed by anteroposterior (AP); lateral (LAT) and medial (MED) acquisitions of 3D ABUS in both breasts. All mammograms were double read by two dedicated breast radiologists. The 3D ABUS was read by the first radiologist immediately after reading the mammograms. The second reader looked at the 3D ABUS only if there was a need for consensus discussion because of unclear or abnormal mammograms or 3D ABUS.

Results: The combined FFDSM and 3D ABUS generated a total of 6.6 cancers per 1000 women screened (95% CI: 3.0, 10.2; p<0.001) compared with 4.2 cancers per 1000 women screened (95% CI) for FFDSM alone. The difference in yield was an additional 2.4 detected cancers per 1000 women screened (95% CI: 0.6, 4.8; p<0.001). The corresponding recall rate per 1000 women screened was 13.8 (95% CI: 9.0, 19.8) for FFDSM alone and 22.8 for combined FFDSM and ABUS (95% CI: 16.2, 30.0), yielding a difference of an additional 9.0 recalls per 1000 women screened (95% CI: 3.0, 15.0; p=0.004).

Conclusion: The addition of 3D ABUS to FFDSM in women with ACR3 or ACR4 breast density significantly improved invasive breast cancer detection rate with an acceptable recall increase.

Keywords: 3D ABUS; Breast cancer detection; Breast cancer screening; Breast density; FFDSM; Recall rate.

Wilczek B, Wilczek HE, Rasouliyan L, Leifland K. Adding 3D automated breast ultrasound to mammography screening in women with heterogeneously and extremely dense breasts: Report from a hospital-based, high-volume, single-center breast cancer screening program. *Eur J Radiol*. 2016;85(9):1554-1563. doi:10.1016/j.ejrad.2016.06.004

Breast Cancer Detection Using Automated Whole Breast Ultrasound and Mammography in Radiographically Dense Breasts

Kevin M Kelly [1], Judy Dean, W Scott Comulada, Sung-Jae Lee

Affiliations + expand

Abstract

Purpose: Mammography, the standard method of breast cancer screening, misses many cancers, especially in dense-breasted women. We compared the performance and diagnostic yield of mammography alone versus an automated whole breast ultrasound (AWBU) plus mammography in women with dense breasts and/or at elevated risk of breast cancer.

Methods: AWBU screening was tested in 4,419 women having routine mammography (

Trial registration: ClinicalTrials.gov Identifier: NCT00649337). Cancers occurring during the study and subsequent 1-year follow-up were evaluated. Sensitivity, specificity and positive predictive value (PPV) of biopsy recommendation for mammography alone, AWBU and mammography with AWBU were calculated.

Results: Breast cancer detection doubled from 23 to 46 in 6,425 studies using AWBU with mammography, resulting in an increase in diagnostic yield from 3.6 per 1,000 with mammography alone to 7.2 per 1,000 by adding AWBU. PPV for biopsy based on mammography findings was 39.0% and for AWBU 38.4%. The number of detected invasive cancers 10 mm or less in size tripled from 7 to 21 when AWBU findings were added to mammography.

Conclusion: AWBU resulted in significant cancer detection improvement compared with mammography alone. Additional detection and the smaller size of invasive cancers may justify this technology's expense for women with dense breasts and/or at high risk for breast cancer.

Kelly KM, Dean J, Comulada WS, Lee SJ. Breast cancer detection using automated whole breast ultrasound and mammography in radiographically dense breasts. *Eur Radiol.* 2010;20(3):734-742. doi:10.1007/s00330-009-1588-y

Limitation of study:

- Small number of patient

- Relative bias of case selection as researcher still along the learning phase of technique during the study.

- ABUS is a recently introduced imaging modality in Egypt with limited number of machine (2 machines install during time of study conduction.

Conclusion:

- ABUS is technological advancement in breast imaging and screening with the benefits of
  1. Standardization of the scan,
  2. Better detection of small lesion especially in patient with dense breast
  3. Improve scan time

- Major drawback : relative high cost of machine compare to convention machine.

Fundings:

- Authors declare study was self funded and no funding was obtain from manufacturer of machine used / from any of its representative / any other organization.

That all from me…….

Thank you for your attention.