

AUTOMATED BREAST ULTRASOUND FOR DENSE BREASTS: RECENT FINDINGS (2020-2025)

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ABSTRACT

The automated breast ultrasound (ABUS) helps for localizing the palpable and non-palpable masses before performing the surgical excision. It is employed as a supplementary tool with the mammography (MG) in view of high incidence of breast cancer and where palpable mass/ fibroglandular tissue in the breast are indicated in women with the improved outcome. Dense breasts make the MGs quite challenging especially in younger women whereas breast ultrasound (BUS)- an imaging technique utilizing the ultrasonography may serve better for screening as well as diagnostic purposes with/ without MGs. The BUS is preferred over MG owing to the reason that ultrasound accompanies no pain and discomfort of the breast compression experienced in MGs. The guidelines for the breast sonography and a variety of breast findings along with final diagnosis usually depend on quite concerning features. The present review provides information about the general aspects of ultrasound, ABUS, MG, elastography, procedure of ABUS, and comparison of ABUS and other techniques. The procedure of the breast ultrasound is a non-invasive, safe, without any complications, and have none or very little special preparation. However, it is highly recommended that the breast ultrasound technician/ radiologist, or the concerned should have the proper clinical and technical expertise for understanding the technique, handling and evaluating the ultrasound imaging. The ABUS presents benefits over the other techniques especially the MG alone. It aids and improves/ overcomes the limitations of MG for dense breast. The procedure of the ABUS is comfortable/ safe and painless just like the ultrasound imaging carried out for children, and the total time required for the ABUS is minimal. The ABUS presents benefits over the other techniques especially the MG alone. It aids and improves/ overcomes the limitations of MG for dense breast. Hence, ABUS along with MG seems the appropriate combinations of two techniques for detecting and diagnosing properly the dense breast cancers.

Key-words: Ultrasound, automated breast ultrasound (ABUS), mammography (MG), elastography, procedure of ABUS, comparison of ABUS and other techniques

INTRODUCTION

The statistical records show that one in each eight women develops the breast cancer in their lifetime (Zaluzec and Sempere, 2024). More sophisticated, effectively and efficiently detecting tools and techniques are essentially required for the breast cancer-one of the most fatal health challenges world over (Trapani *et al.*, 2022; Wilkinson

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and Gathani, 2022). Continuous exposure in mammography (MG) screening requires an additional diagnostic tool that may decrease the dangerous risks but may increase the detection abilities e.g., in women with dense breasts where sensitivity is significantly decreased (Barrios, 2022).

The tissue composition of the breasts in homogenous background echotexture is categorized as: majority of fat containing tissues, echogenic fibroglandular tissues under fat, and the tissues having various extent of echogenic texture that makes the lesions as uncertain, whereas lesion mass assessment requires to report the orientation (parallel/ not parallel), shape (round, oval, irregular), pattern of echo (heterogenous, complex cystic and solid, hypoechoic, hyperechoic isoechoic etc.), location of presence of calcification, posterior features, shadowing, enhancement, combined patterns with mixed shadowing and enhancement patterns, and circumscribed or non-circumscribed margins (Malherbe and Tafti, 2025).

The breast ultrasound (BUS) helps for localizing the palpable and non-palpable masses before performing the surgical excision (Toyoda *et al.*, 2020). It is employed as a supplementary tool with the MG in view of high incidence of breast cancer and where palpable mass/ fibroglandular tissues in the breast are indicated in women with the improved outcome (Malherbe and Tafti, 2025).

In view of the mentioned features to be diagnosed properly, there is an extreme need and interest of developing the cost-effective and more robust complementary BUS (CBUS) to improve three-dimensional ABUS (3D ABUS) for the uniformity of special resolution employing conventional ultrasound transducer for additional screening in the high-risk population with dense breasts to have orthogonal images and diagnostic overall utilization (Park *et al.*, 2025). For obtaining the better screening results in women with dense breasts, performance of the ABUS with same day MG (ABUS/MG) and handheld ultrasound (HHUS) with same day MG (HHUS/MG) were compared (Winkelman *et al.*, 2024). A study was conducted to compare the ABUS, abbreviated MRI and contrast enhance MG for the care for women with dense breasts and a negative MG (Gilbert *et al.*, 2025).

It is valuable to assess the characteristics and the number of cancers in women diagnosed by ABUS that are not detectable by MG (Paul *et al.*, 2025). Various breast cancer screening methods for screening performance were compared and the applicability of ABUS for the people having low medical resources was investigated (Niu *et al.*, 2025).

There is a need of determining the strategic effectiveness for firm evidence of the efficacy of screening procedures in women with high prevalence of the dense breasts in view of the notable absence of the efficacy of ultrasound-based screening (Xu *et al.*, 2024). The status of the ABUS is impressive for detecting along with diagnosing mammographically the breast Imaging reporting and data system (BI-RADS) category 4 of microcalcifications (Yu *et al.*, 2024).

Breast evaluation for dense breast and the detection and diagnosis of breast cancer in low resource conditions is widely done by the primary supplemental screening tool of ultrasound- incorporating the whole breast HHUS, or ABUS. However, the modern artificial intelligence approaches introduced recently have provided a better facility to the radiologists for detecting and diagnosing the breast lesions on the ultrasound (Villa-Camacho *et al.*, 2023). The present review provides information about the general aspects of ultrasound, ABUS, MG, elastography, procedure of ABUS, and comparison of ABUS and other techniques.

BREAST ULTRASOUND

Breast ultrasound (BUS) is considered as the practical and valuable solution for the breast disease, and it has shown its importance as a part of supplementary breast screening tool (Malherbe and Tafti, 2025). Dense breasts make the MGs quite challenging especially in younger women whereas BUS- an imaging technique utilizing the ultrasonography may serve better for screening as well as diagnostic purposes with/ without MGs.

The BUS is preferred over MG owing to the reason that ultrasound accompanies no pain and discomfort of the breast compression experienced in MG. The guidelines for the breast sonography and a variety of breast findings along with final diagnosis usually depend on quite concerning features (Malherbe and Tafti, 2025). There are several morphological features to be examined by ultrasound (Tutar *et al.*, 2020). These features are observed and compared in benign sonographic examination (Flory *et al.*, 2020) and malignant sonographic examination (Vincent-Salomon *et al.*, 2020; Malherbe and Tafti, 2025).

MAMMOGRAPHY

Mammography (MG) that uses the low energy X-rays for early detection of breast cancer produces MG of the breast tissues in women with/without symptoms of disorders. Low dose X-rays are used by MG to have the breast tissue images, and early detection decreases the mortality owing to breast cancer, though the net beneficial effect depends on age (Farkas and Nattinger, 2023). The important purpose of MG is the early detection of breast cancer.

Screening MG and diagnostic MG are generally used. The risk reducing drugs provide benefit to women having increased risk of breast cancer (Farkas and Nattinger, 2023).

Main types of MG are: digital, three dimensional (3D), contrast-enhanced, photon counting and galactography. The benefit of MG is that it can detect early-stage cancers not felt by a woman or her doctor that helps early management and provides better outcomes. Whereas its demerits include false positive or negative results, and radiation exposure although it uses low dose of X-rays. The breast tissue density (ratio of the glandular with connective tissue to the fatty tissue) that influence the efficacy of MG varies among women (Kwon *et al.*, 2024). The MG sensitivity decreases especially for dense breasts e.g., extremely dense or heterogenous breast tissues (Gabrielson *et al.*, 2014; Winkelman *et al.*, 2024). In view of that, the MG remains unable to detect some of the cancers leading to delayed diagnosis and management.

ELASTOGRAPHY

The current and future perspectives related to the clinical and technological advancements in the BUS elastography reveal the ultrasound elastography as a potential and promising tool for early detection of breast cancer (Zhou *et al.*, 2025). It is a non-invasive imaging technique that employs ultrasound to determine the elasticity for determining the tissue stiffness and tumors and offers additional data to conventional ultrasound of B-mode (Hong *et al.*, 2021; Ansari *et al.*, 2023; Zhou *et al.*, 2025). It maps deformed tissue under pressure (stiff tissues often appear in blue color in the image). Two important techniques of elastography are ultrasound elastography and magnetic resonance imaging (MRI) for measuring stiffness and anatomical imaging respectively. The capability of ultrasound elastography are enhanced after incorporating the artificial intelligence for achieving more than 80% sensitivity for tumor classification (Mao *et al.*, 2022).

AUTOMATED BREAST ULTRASOUND (ABUS)

The terms Automated breast ultrasound (ABUS) and automated whole breast ultrasound (AWBU) are not the different technologies. Rather ABUS involves scanning of the whole breast and is the term that generally represent the whole breast scan or AWBW. The older and white population of women with dense breasts were found to be around 40% using ABUS (Paul *et al.*, 2025). The AWBS is a technique for having volumetric images of breast, and it indicates the automated process to scan the entire breast in contrast to just a localized or operator-depending scan of the type of HHUS.

The ABUS that is a Food and Drug Administration (FDA)-approved supplemental screening technique, is a valuable tool that provides an improved image for screening the dense breast tissues, provides 3D ultrasound and non-operator depending, reproducible and standard scan of the whole breast. There are several studies that describe the ABUS with/ without supplementary tools (Berg, 2020; Winkelman *et al.*, 2024; Xu *et al.*, 2024; Yu *et al.*, 2024; Gilbert *et al.*, 2025; Malherbe and Tafti, 2025; Niu *et al.*, 2025; Park *et al.*, 2025).

PROCEDURE OF ABUS

The ABUS gives the coronal or vertical view with a specific anatomical visualization helping cancer detection with high output and to providing aid for the surgical planning. The woman is being laid on the examining table. The water-soluble ultrasound lotion is applied and the padded curved transducer is placed upon the breast for having consistent good contact, getting rid of artifacts and obtaining the standard quality of the scan. The comprehensive 3D images of the breast are obtained by the machine that moves to scan the whole breast. The upper half of trunk is undressed, loose clothing is worn, and any jewelry in the area of examination is removed before ultrasound examination (Malherbe and Tafti, 2025).

The ABUS has an automated process for automatic scanning that employs sound waves for generating 3D breast images, and it is a quick, non-invasive and comfortable imaging technique that produces detailed images for the radiologist for his/ her detailed review of high-resolution monitor and to identify any specific concerned areas of the breast. Some of the technical or procedural details (Malherbe and Tafti, 2025) are: a) three measures of the lesion are performed with nearest centimeters or millimeters, from the longest axis, perpendicular to the longest axis and the orthogonal to first two measures, b) for follow up, 'o clock' position is marked for any identified lesion in the outer upper, lower outer, outer inner and lower inner breast quadrants, c) by angling probe in the direction of retroareolar ducts, or changing the controls for tissue gain compensation and employing the gel standoff pad having little focal zone, can help overcoming the anatomical limitation (Pushkin and Berg, 2020; Malherbe and Tafti, 2025).

The mobile image software connected without wires with the stand alone the linear frequency probe, computer-based detection to segment and identify the lesions with enhanced diagnostic value, and production of focal zone

depths, overall gain, and measures for time-gain compensation for the assessment of lesion masses, are some of the recent advances in the technology from ultrasound vendors (Bick *et al.*, 2020; Malherbe and Tafti, 2025).

COMPARISON OF ABUS WITH OTHER TECHNIQUES

It was found that ultrasound provides better diagnostic accuracy than MG for those women having denser breasts. The ABUS was found more helpful for diagnosing the malignant tumors compared to HHUS (Niu *et al.*, 2025). The ABUS uses sound waves for creating 3D-images of the whole breast for the purpose of improving the cancer detection rates unlike the traditionally used HHUS, and the MGs alone have less effectivity. It is beneficial for women having dense breast tissues whereas the MG reveals decreased sensitivity in certain areas in the breast for proper detection of cancers in the dense breast tissues. The detection rate for the breast cancers in the dense breast tissues by ABUS is more compared to MG alone. Comparisons of the performance of ABUS with same day MG (ABUS/MG) and HHUS with same day MG (HHUS/MG) showed that the ABUS/MG provided a similar sensitivity but slightly higher specificity than that of HHUS/MG (Winkelman *et al.*, 2024).

The MG serves as the gold standard for the screening of breast cancer, though there are certain imaging limitations with dense breasts, and hence, ultrasound as well as magnetic resonance imaging (MRI) have supplementary role for breast screening (Esmaeili *et al.*, 2020; Malherbe and Tafti, 2025). Furthermore, the detection sensitivity for breast cancers for MG and ultrasound enhances to 97.3% and estimated false positive rate results found by ultrasound were 2.4%. (Berg, 2020; Malherbe and Tafti, 2025). However, the detection by the abbreviated MRI and contrast-enhanced MG was three times more invasive half the size cancers while compared to ABUS (Gilbert *et al.*, 2025).

Despite that, the ABUS is considered as the effective diagnostic tool for obtaining the information of the extent of known types of cancer and monitoring the tumor growth rate in chemotherapy. The combination of single images of three-dimensional complementary breast ultrasound (3D CBUS) showed improvement for the images of 3D ultrasound considering resolution for out of plan. It was noted that using the commercial ultrasound transducer helped improvement of the uniformity of 3D spatial resolution for the orthogonal images and that is a potential supplemental screening and diagnostic application for women with dense breasts (Park *et al.*, 2025).

It was investigated that the ABUS showed better results compared to the HHUS for the breast cancer screening (Xu *et al.*, 2024). Furthermore, the ABUS was found having higher sensitivity than MG especially in dense breast for mammographically BI-RADS category-4 malignant microcalcification (Yu *et al.*, 2024).

CONCLUSIONS

The procedure of the breast ultrasound (BUS) is a non-invasive, safe, without any complications, and have none or very little special preparation. However, it is highly recommended that the BUS technician/ radiologist, or the concerned consultants should have the proper clinical and technical expertise for understanding the technique, handling and evaluating the ultrasound imaging (Malherbe and Tafti, 2025). It is important to examine both longitudinal and transverse planes for the lesions along with its location, echogenicity for all masses (hyperechoic, hypoechoic or heterogeneous) and measurements using various morphological descriptors (Tutar *et al.*, 2020).

It is necessary to examine and compare the anatomical features. The benign sonographic examination indicates various morphological characteristics including echogenicity as isoechoic, hyperechoic, or moderate hypoechoic; margins as well-circumscribed and smoothy; shape appearance as ellipsoid, and more wide than tall; enhancement of posterior acoustic structure; echogenic capsule with well-defined border and thin in appearance, and margin of less than three lobulated or a large, rounded, and undulating or scalloped contour (Flory *et al.*, 2020). Whereas the malignant sonographic features commonly observed are: margins as spiculated, borders not clearly defined, posterior acoustic shadowing, appearance as taller than wider, masses as hypoechoic and in certain occasions as hyperechoic, and the presence of microcalcifications (Vincent-Salomon *et al.*, 2020; Malherbe and Tafti, 2025).

The ABUS presents benefits over the other techniques especially the MG alone. It aids and improves/overcomes the limitations of MG for dense breast. The procedure of the ABUS is comfortable/ safe and painless just like the ultrasound imaging carried out for children. The total time required for the ABUS is just around 15 minutes. Hence, ABUS along with MG seems the appropriate combinations of two techniques for detecting and diagnosing properly the dense breast cancers.

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