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To cite this article:

Ivanova, E., Matev, B., & Baneva, Y. (2025). Automated breast ultrasound for breast lesion detection - Literature review. *International Journal on Engineering, Science, and Technology (IJonEST), 7*(2), 107-117. https://doi.org/10.46328/ijonest.5890

International Journal on Engineering, Science, and Technology
2025, Vol. 7, No. 2, 107-117 https://doi.org/10.46328/ijonest.5890

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Article Info

Article History

Received:
11 August 2025
Accepted:
10 November 2025

Keywords

ABUS
Breast ultrasound
AI in radiology
Breast cancer
Cancer screening

Abstract

Early breast lesion detection is crucial for women. According to WHO, breast cancer caused 670 000 deaths globally in 2022. Mammography is one of the best screening tools for early breast cancer detection. Still, with a dose between 3 and 5 mGy to the glandular tissue for a typical mammographic screening examination involving two views of each breast, alternatives might be used if not necessary. Breast ultrasound is an option, especially in young patients and those with dense breasts. This paper aims to present the little-known automated breast ultrasound (ABUS) as a viable alternative to the conventional handheld ultrasound. A literature review was conducted using the keywords “automated breast ultrasound," "ABUS," "ABVUS," and "sonotomography" in the online databases Google Scholar, PubMed, and Web of Science. The review yielded a total of n=267 studies, of which n=83 were considered pertinent. The review was also based on the clinical experience using an ABUS machine at St. Marina University Hospital—Varna (UMHAT “St. Marina Varna”). ABUS is not widely used in most radiology clinics, even dedicated breast clinics. Automated ultrasound is a machine controlled by an X-ray technician or an ultrasonographer, which records a series of breast ultrasound images. The main advantage of the modality is the elimination of operator dependence (with some caveats, which are expanded upon in the “discussion section”), as well as the reduction of subjectivity. If previous studies are available, precise follow-up of the size and localization of breast lesions is possible. However, a suitable additional screening method, ABUS, demonstrates some disadvantages as a diagnostic tool. Some of the limitations are the absence of information for vascularization and the elasticity of a lesion. Possible artefacts include, but are not limited to, retro-areolar shadowing, breathing artefacts, and air interposition between the probe and the skin. ABUS is applicable for screening and follow-up modality, especially in settings with a large patient base or an absence of trained personnel.

Introduction

Breast cancer occurs in every country in the world and affects women of all ages, with the incidence increasing after the age of 50. Although screening programs vary between countries, mammography is recognized as the gold standard for breast cancer detection, having demonstrated a 20% reduction in mortality (Icanervilia et al., 2025). However, mammography is not always sensitive enough, and additional imaging is often needed in women with dense breasts. Tomosynthesis, ultrasound and magnetic resonance imaging are the most widespread modalities. A disadvantage of mammography and tomosynthesis is exposing the patient to ionizing radiation - mean glandular dose between 3 and 5 mGy per view. Although radiation-free, MRI is an expensive and time-consuming method. Ultrasonography is an inexpensive and widely used method of supplementary imaging and consists of two subtypes: handheld ultrasound and automated breast ultrasound.

Automated breast ultrasound (ABUS) represents a new imaging technique approved by the Food and Drug Administration (FDA) in 2012 as a supplemental screening tool for women with heterogeneously and extremely dense breasts (Boca et al., 2021). It is a standardized technique that is operator-independent and reproducible and has a similar diagnostic performance to handheld ultrasound (HHUS) (Al Jahed et al., 2022). The examination can be performed in the supine or prone position and lasts from 5 to 20 minutes depending on the number of volumes obtained - a minimum of 3 and up to 6 views. A trained ABUS radiographer uses a specialized probe to obtain three-dimensional images of the breast. A special water-based gel, different from the standard ultrasonography gel, is used to maximize skin contact.

With ABUS, there is little radiologist operator dependency and unlike HHUS, there is no limited set of stored images. ABUS allows evaluation of the whole volume of breast tissue uncoupled from the time of image acquisition, enabling a double reading approach (Lee et al., 2019). Software allows images to be stored and compared at follow-up. To our knowledge, ABUS has relatively limited familiarity among radiologists. In this article, we aim to summarise some of the available literature on the subject and share our experience with the method.

Method

A literature review was conducted using the keywords "automated breast ultrasound", "ABUS", and "sonotomography" in the online databases Google Scholar, PubMed, and Web of Science. The review yielded a total of n=267 studies, and n=83 were considered pertinent. The review was also based on the clinical experience using an ABUS machine at St. Marina University Hospital—Varna.

Results

History of Breast Ultrasound

High-frequency ultrasound was first used in World War II to detect metal particles during operations. After years of research, the first ultrasound for the diagnosis of breast lesions in clinical work was introduced in 1954. In the beginning, expectations for the method did not include making it a screening one but rather differentiating malignant from benign lesions. In the following decades, research into the technique spread internationally, particularly in Australia, the USA and Japan. A significant improvement was the introduction of greyscale ultrasound in 1969 - an innovation that allows differentiation of the soft tissues of the mammary gland. The first studies to look for breast lesions in asymptomatic patients are concluded.

During the 1960s, Wells and his group in England constructed a machine, unique at the time, which used a prone scanning technique with the patient's breast suspended in a temperature-controlled water bath (Dempsey, 2004). A supine version was designed by Kossoff, Jellins - breast scanner, in which an enclosed water bath with a probe within is being lowered to the patient's chest (Goldberg, 1988), reminiscent of the modern ABUS.

Switching from analogue to digital signal in the 1980s provided better image resolution. In the following years, the most significant technical advances in breast imaging are made by developing the tissue-harmonic and Doppler signal. One of the most commonly used features of modern ultrasound equipment is elastography. It is a preferred method for characterizing lesion stiffness - often providing valuable information about the potential malignancy of the finding. There are two main types of ultrasound-based elastography - strain elastography (where mechanical pressure is applied) and shear wave elastography (which uses an additional source of ultrasound waves).

Nowadays, ultrasound also plays an essential role in detecting and characterizing axillary lymph nodes. Direct visualization of lymph nodes and cystic or solid lesions in the mammary gland allows biopsies to be performed under ultrasound guidance. These are subdivided into fine-needle, tru-cut and vacuum-assisted.

ABUS vs Conventional Breast Imaging: Clinical and Technical Comparison

Breast imaging is a mainstay in the early detection and diagnosis of breast cancer. For women with dense breast tissue, conventional imaging methods such as mammography and handheld ultrasound (HHUS) often fall short in sensitivity. Automated Breast Ultrasound (ABUS) is an emerging alternative (Vourtsis, 2019).

Mammography is almost universally applied as a gold standard in breast cancer screening owing to its high reproducibility, availability and cheap cost. Studies indicate that the sensitivity of mammography decreases from approximately 86% in fatty breasts to less than 61% in dense breasts. Dense breast tissue not only obscures lesions but also independently increases the risk of breast cancer, with women having extremely dense breasts (ACR categories C and D) facing a 4.7-fold higher risk compared to those with fatty breasts (Hooley et al., 2012). Mammography is generally reproducible and consistent across users but does not adapt well to individual breast tissue composition (Brem et al., 2015).

HHUS is commonly used as a supplemental technique to mammography. It is capable of detecting cancers that mammography may miss in dense breast tissue. It is non-ionizing and offers improved sensitivity (~70–80%) compared to mammography in dense breasts. However, HHUS is highly operator-dependent, requiring skilled technologists or radiologists to scan and interpret the images, which affects reproducibility. The quality of imaging and completeness of examination can vary significantly.

ABUS is a machine-operated imaging modality designed to reduce operator variability. It offers standardized imaging and higher reproducibility. Recent data show that ABUS has a sensitivity of 80–95% and a specificity of

85–90% in women with dense breasts. ABUS provides improved diagnostic accuracy, as demonstrated in studies such as Winkelman et al. (2024) and Xu et al. (2025), with ABUS showing higher specificity and lower biopsy recommendation rates compared to HHUS. Though it does not provide vascular information like contrast-enhanced ultrasound (CEUS), its standardization makes it ideal for large-scale screening programs. It provides three-dimensional imaging capabilities, enhancing lesion detection, especially in dense breast tissue (Wilczek et al., 2016).

ABUS distinguishes itself from HHUS through its automated image acquisition process. HHUS is highly reliant on the operator's skill (a radiologist or trained sonographer in some instances), leading to variability in image quality and interpretation. ABUS, on the other hand, utilizes a mechanized transducer to scan the entire breast systematically. While this process reduces differences in acquisition, it does not completely eliminate operator dependency but merely shifts it in the way of the radiographer. This automation itself ensures relatively consistent image quality and reproducible measuring parameters (Wilczek et al., 2016).

Technical Specifications

• Imaging Planes: ABUS acquires volumetric data that can be reconstructed into multiple planes, including transverse, sagittal, and coronal views. The coronal plane, in particular, offers a 'surgical view' that aids in the assessment of architectural distortions and lesion margins.

• Transducer Types: ABUS systems typically employ high-frequency linear array transducers ranging from 6 to 14 MHz. These transducers are attached to a rigid compression plate to ensure uniform contact and compression across the breast tissue.

• 3D Reconstructions: The automated scanning process captures hundreds of sequential images, which are then reconstructed into a three-dimensional dataset. This 3D volume provides an additional perspective that increases interpretation speed and offers invaluable surgical planning.

Imaging Physics and Technique

• Mammography: This X-ray-based modality relies on compression. It is best for detecting microcalcifications but loses sensitivity in dense tissue. It is important to note that variations such as tomosynthesis and contrast-enhanced mammography exist but are beyond the scope of this presentation.

• HHUS: Uses real-time high-frequency sound waves (5–15 MHz), offering high precision in cystic vs. solid mass differentiation, but highly operator-dependent. Complementary methods such as Doppler ultrasound and elastography can only be used in HHUS (for the time being)

• ABUS: Automated 3D ultrasound using 7–14 MHz, standardizes acquisition with volumetric reconstruction, excellent for the screening of dense breasts, but somewhat anatomy-dependent.

Operator Influence and Reproducibility

• Mammography: Minimal operator variation and quick training time. Least influenced by breast size, most influenced by breast density.

• HHUS: High operator variability; interpretation depends on radiologist skill. Most influenced by breast size, least influenced by breast density.

• ABUS: Low to medium acquisition variability; radiologist still interprets 2D/3D dataset. Moderately influenced by breast size and breast density.

Our experience

As part of the Radiology Department of the University Multiprofile Hospital for Active Treatment "St. Marina" in Varna (UMHAT "St. Marina"), we have the opportunity to work with ABUS on a daily basis. The machine was installed in 2017, and since then, about 840 examinations have been performed, mainly for screening and follow-up of breast lesions. The main target group of patients are women under 50 years of age (starting age for mammograms in Bulgaria). If further clarification of a finding is needed, HHUS, MRI in the facility or mammography in the outpatient setting is performed.

Our hospital is the second largest in Bulgaria, so the daily flow of patients is significant. At the same time, there is a shortage of board-certified radiologists. Routine HHUS by experienced radiologists is impossible due to the extremely high workload. The ability to read images at a time independent of their acquisition is the most significant advantage of ABUS that we benefit from.

The examination is performed by a specially trained X-ray technician on a pre-specified date -10-12 days of the menstruation cycle of the patient. Before the start of the ultrasonography, the laboratory technician takes a patient's history using a specially prepared questionnaire. After that, the patient removes her clothing from her upper body and lies supine on the bed with her hands above her head.

The laboratory technician coats the breasts with a specially tailored ABUS gel and applies the transducer. Both breasts are sequentially scanned in 6 projections: superior, inferior, medial, lateral, frontal, and axillary. Depending on the size of the breasts, the scan takes 20 to 30 minutes. The images are sent to a station specifically suited to interpretation.

Discussion

Pros of ABUS

Multiple studies suggest that ABUS is an effective screening modality in dense breasts. EUSOBI (European Society of Breast Imaging) guidelines suggest the possible usage of supplemental ultrasound screening in women at average or intermediate risk with dense breasts and negative mammography (Marcon et al., 2024). SomoInsight is the most extensive study that assessed the diagnostic performance of ABUS in a screening scenario, including 15.318 asymptomatic women with dense breasts. By associating ABUS with FFDM, the increase in the detection rate was 1.9 per 1000 women, increasing sensitivity by 26.7%. (2)

Saving Time and Money

In contrast to the HHUS, which requires 15 to 20 minutes for the examination, the interpretation time for the ABUS is much shorter. A study from Huppe et al. reported an average ABUS interpretation time of 3 minutes by radiologists of all experience levels (Huppe et al., 2018).

The fact that ultrasonography does not put an additional and unnecessary burden on the health system budget is controversial, and several extensive studies have been done on the issue. Foglia et al. compared three scenarios: mammography with a further examination if a finding is detected, mammography in combination with HHUS and mammography in combination with ABUS. The results show that the latter scenario could save the Italian healthcare system €54 million (Foglia et al., 2020).

Possibility of Reconstructions and Use of CAD (Computer-Aided Detection)

ABUS software provides coronal reconstructions. These images are instrumental in visualizing and tracking dilated ducts. They are beneficial when planning surgery.

Integrating AI (artificial intelligence), specifically CAD, into breast disease diagnosis aims to reduce interpretation time and increase accuracy. One of the studies comparing the two parameters in ABUS is by Jiang et al. (2018). It is a retrospective study in which 185 screening ABUS cases were evaluated with and without the aid of CAD. The results show that while accuracy was not affected, the interpreting time was reduced by about one minute.

A study by Lee et al. (2022), including 846 cases, analyzed the characteristics of CAD markers and the causes of false-positive markings. A large number of false-positive markings is found - 530 out of 1032. A significant proportion of these are clearly distinguishable as pseudolesions, e.g. shadowing from Cooper's ligament, periareolar shadowing.

Reproducibility of Images and Follow-up

ABUS has excellent reproducibility in terms of lesion location, size, and characteristics. This feature makes it very suitable for following up on findings. Chang et al. (2015) performed ABUS scanning of both breasts twice with a mean interval of 1.3 days in 24 patients. The localization (clockwise orientation and distance from the mamillae) and size indices showed excellent reliability—the corresponding ICCs were 0.994, 0.926, and 0,980.

According to a study by Hatzipanagiotou et al. (2022), ABUS is non-inferior to HHUS in predicting pathological complete response after neoadjuvant chemotherapy.

Cons

Artifacts

Some of the known ABUS artefacts are presented, accompanied by images from our PACS.

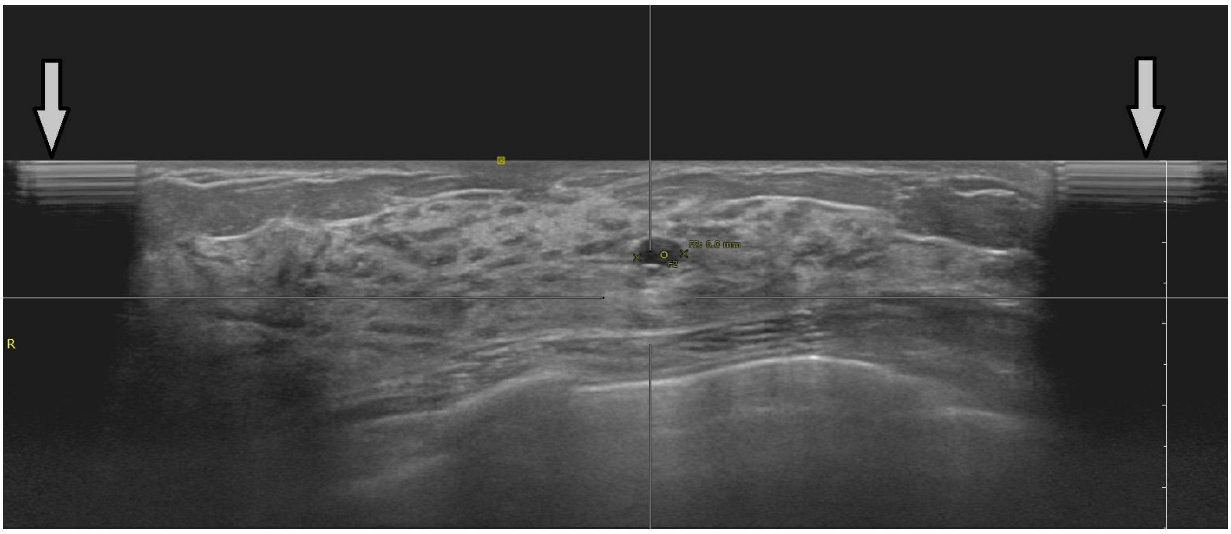

Figure 1 Compression Artefact in an Image with a Fibroadenoma

A *compression artefact* (Fig. 1) occurs in cases of insufficient tissue compression. Anechoic zones due to air interposition appear at the edges of the image, severely hampered interpretation of the breast tissue beneath these artifacts.

Figure 2 Air Interposition Artefact in a 3D Reconstruction

An *air interposition artefact* (Fig. 2) occurs in cases of unevenly distributed ultrasound gel over the skin. Air pockets that remain in the gel scatter the ultrasound rays and appear as anechoic zones.

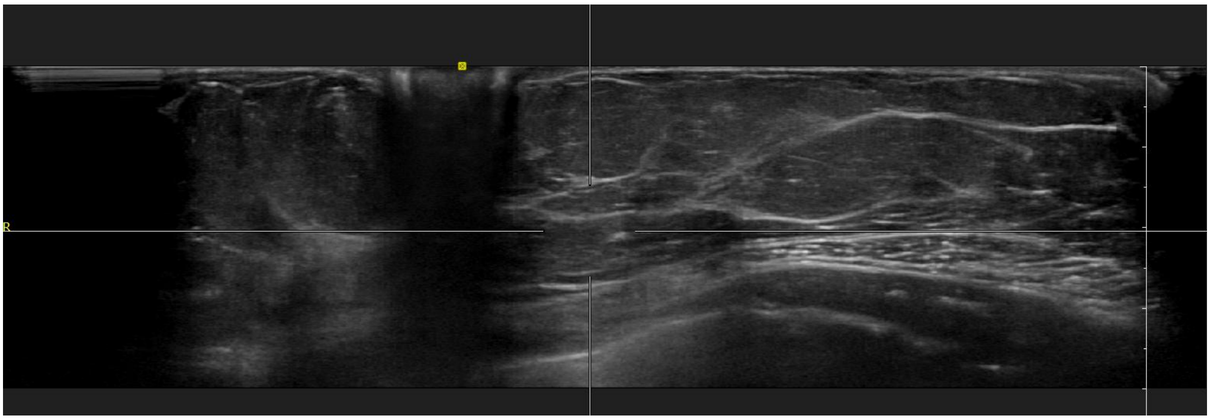

Fig. 3 Retroareolar shadowing.

A *retroareolar shadowing artefact* (Fig. 3) occurs in cases of irregular or inverted nipples and represents zones of posterior shadowing which obscure the underlying parenchyma. This specific artefact frequently requires HHUS follow-up due to the particular area where it occurs.

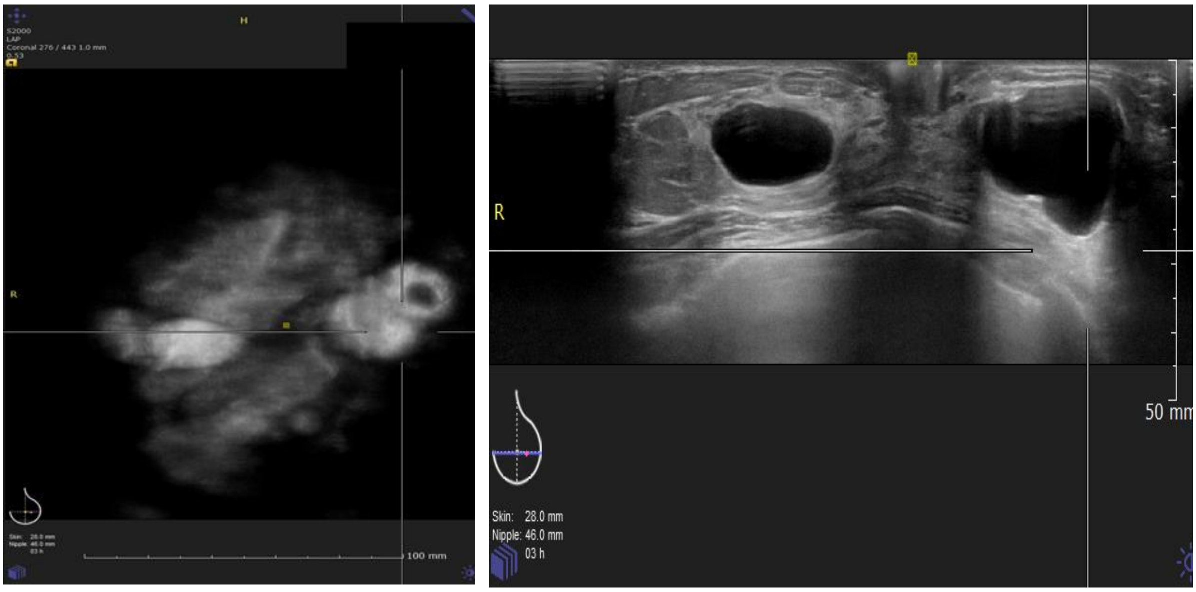

Figure 4 White Wall Artefact

A *white wall artefact* (also referred to as a white wall sign) surrounds lesions/zones of liquid. It is analogous to zones of "posterior enhancement" or "waterfall sign" due to the amplification of ultrasound waves when passing through the liquid.

Conclusion

In conclusion, while mammography remains the first-line screening tool, its limitations in dense breast tissue highlight the need for supplemental imaging. HHUS, although valuable, introduces variability due to its operator dependency. ABUS offers a compelling solution with higher reproducibility, improved cancer detection rates, and better integration into standardized clinical workflows. ABUS should be viewed as a vital component in the future of breast cancer screening, especially for women with dense breasts.

A further, previously unexplored aspect of ABUS is the ease of integrating AI and neuronal network solutions. Further studies are needed to explore the possibilities of implementing such options.

Recommendations

ABUS is a useful supplementary screening tool to mammography for breast cancer in women with an ACR density >B as it could save both time and resources in comparison to HHUS.

ABUS could be used interchangeably with HHUS in the screening of women with a high-risk profile for breast cancer when the patients are too young for mammography, as it could save both time and resources in comparison to HHUS.

Due to the high reproducibility of results, ABUS could be a useful tool in following up on Bi-RADS 3 lesions. Any suspected new lesion or suspected change of lesion morphology should be confirmed by HHUS before changes to patient management are made (except for very high suspicions of malignancy or inflammatory changes, which could prove to be time-dependent).

ABUS should be viewed as a supplementary tool to HHUS rather than a complete replacement, and there should be an emphasis on integrating it with AI solutions.

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