

Clinical Application of Artificial Intelligence-based Computer-Aided Diagnosis (AI-CAD) to Automated Breast Ultrasound (ABUS)

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Automated breast ultrasound (ABUS) was developed to overcome the operator dependence and limited reproducibility of conventional handheld ultrasound while preserving its diagnostic strengths. Standardized image acquisition by technologists enables consistent coverage of the whole breast and more efficient interpretation by radiologists. In addition, multiplanar reconstructions—particularly the coronal view—provide a wide field of view that improves lesion detection and characterization, making ABUS a useful supplemental screening tool to mammography. However, the large volume of image data may prolong reading time and increase inter-reader variability. To address these challenges, artificial intelligence-based computer-aided diagnosis (AI-CAD) systems have introduced into ABUS workflow. By rapidly analyzing large datasets and highlighting suspicious lesions, AI-CAD has demonstrated improvements in workflow efficiency and diagnostic consistency. Prior studies have reported reduced reading time and improved diagnostic performance, with a particularly greater benefit among less-experienced readers.

This article reviews current evidence regarding the clinical utility of AI-CAD for ABUS, focusing on clinical advantages, key considerations, and potential pitfalls.

Index words: Breast; Automated breast ultrasound; Artificial intelligence; Computer-aided diagnosis

Introduction

Mammography is the primary screening method for breast cancer. However, the sensitivity of mammographic screening is reduced in women with dense breasts, making early detection more

challenging. In such cases, fibroglandular tissue may obscure small cancers, leading to false-negative mammographic results and delayed diagnosis. To address this limitation, large prospective trials have demonstrated that adjunct handheld ultrasound (HHUS) can improve cancer detection by identifying small, node-negative invasive cancers that are mammographically occult (1-3).

Despite these advantages, conventional HHUS is inherently operator-dependent, resulting in variability in image acquisition and interpretation. The examination is time-consuming and lacks

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reproducibility, which limits its utility as a standardized screening tool (4). To overcome these limitations, the automated breast ultrasound (ABUS) was developed to provide automated, standardized, and reproducible whole-breast imaging. ABUS acquires three-dimensional volumetric datasets of the entire breast under uniform and consistent compression using a wide transducer, allowing multiplanar reconstruction and coronal imaging for comprehensive lesion assessment (5). The orientation and characterization of lesions can be evaluated more objectively, and improved reproducibility facilitates reliable comparison on follow-up examinations. In addition, the acquisition process requires only minimal training for technologists (6, 7).

While ABUS is an efficient screening tool with diagnostic performance comparable to HHUS (5, 8), the large imaging volume can increase interpretation time and reader variability. Therefore, artificial intelligence-based computer-aided detection and diagnosis (AI-CAD) has been introduced as a technological solution to improve diagnostic efficiency and consistency (9).

Most previous studies have evaluated QVCAD (QView Medical Inc., USA), one of the ABUS-dedicated CAD systems developed in the United States. Recently, a new commercially available AI-CAD software program using deep neural network techniques, LUCAS-ABS (Monitor Corporation, South Korea), has been introduced and is increasingly adopted in clinical practice, with several studies conducted to assess its performance (10).

AI-CAD can rapidly analyze large volumes of ultrasound data, helping expedite interpretation and reduce radiologist workload (11-13). In addition, AI-CAD ensures consistent image interpretation, which is particularly important in clinical settings where radiologists may have varying levels of experience and expertise.

The objective of this article is to highlight the advantages of applying AI-CAD to ABUS

interpretation and to discuss key considerations and potential pitfalls that may affect its clinical implementation.

1. Why AI-CAD in ABUS

Time Efficiency in Daily Workflow

AI-CAD significantly reduces interpretation time by automatically localizing suspicious lesions within the large volumetric datasets of ABUS. By pre-localizing potential abnormalities, the system directs radiologists' attention to relevant regions, minimizing the need for exhaustive manual review of entire volumes. This streamlined reading process improves workflow efficiency, reduces fatigue, and allows radiologists to dedicate more time to the evaluation of complex or challenging cases.

Several studies have reported that concurrent AI-CAD reading reduces interpretation time without compromising diagnostic accuracy. According to Yang et al. (12), the use of CAD in concurrent-reading mode reduced reading time by approximately 32% (from 50 seconds to 34 seconds per volume) for all readers, while improving the area under the receiver operating characteristic curve (AUC) compared with readings performed without CAD. Similarly, Jiang et al. (13) demonstrated a 33% reduction in interpretation time (from 3 minutes 33 seconds to 2 minutes 24 seconds per case), resulting in a mean time savings of 1 minute 9 seconds (95% CI, 44-93 seconds; $p = 0.000014$). The most substantial efficiency gains have been observed in negative or screening examinations, enabling radiologists to review a greater number of patients within the same time frame. Importantly, AI-CAD systems maintain or may even improve diagnostic performance while enhancing overall workflow efficiency, demonstrating that time savings do not come at the expense of accuracy.

Improving Diagnostic Accuracy

AI-CAD enhances diagnostic performance by assisting radiologists in the detection and characterization of subtle lesions. The system can highlight faint or small hypoechoic lesions that

might otherwise be overlooked, thereby increasing sensitivity and reducing the risk of missed cancers (Fig. 1).

Furthermore, AI-CAD promotes consistency in the assessment of lesion margins, shape, and echogenicity, leading to improved inter-reader

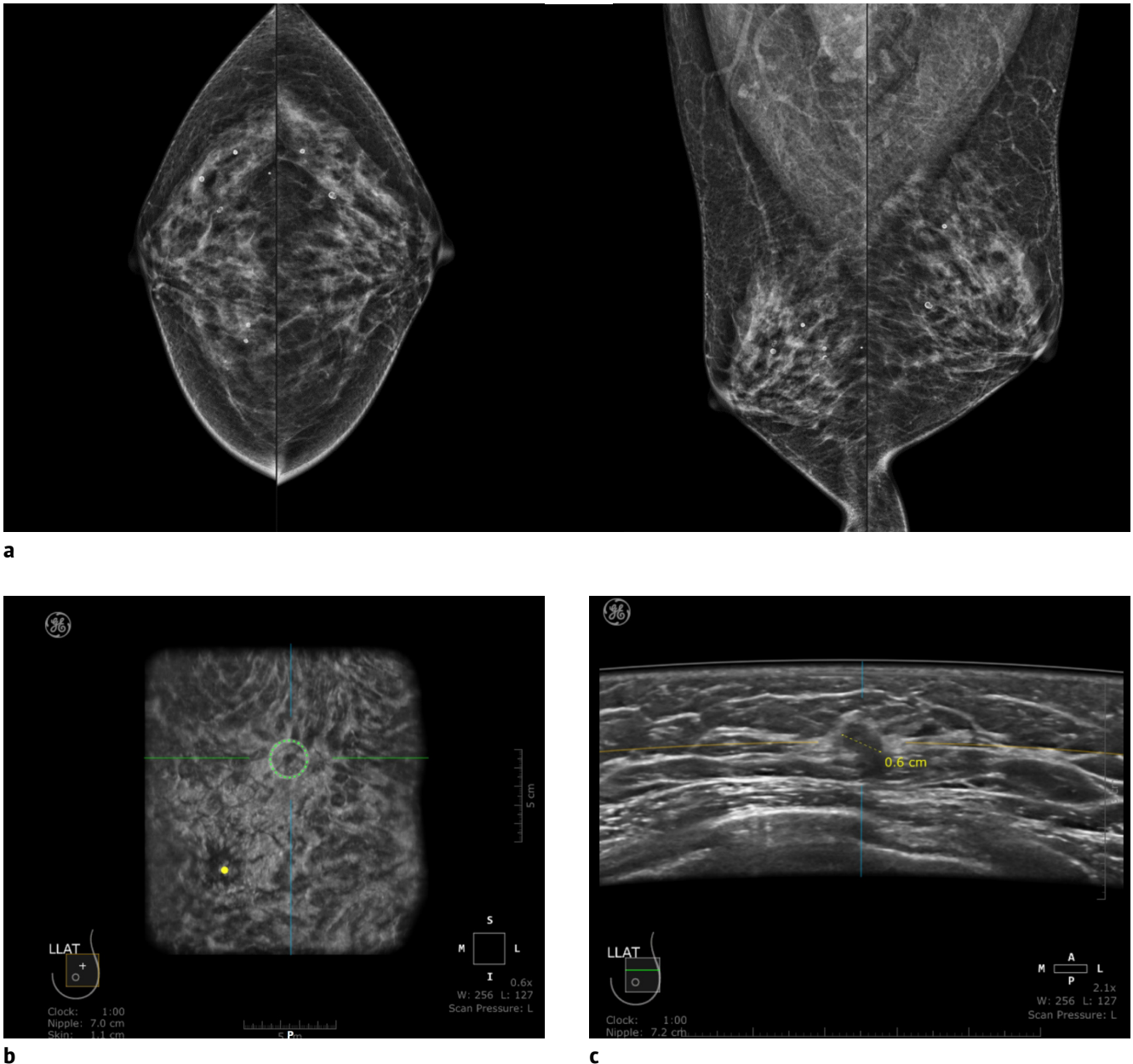


Fig. 1. Mammography and automated breast ultrasound (ABUS) images of a 55-year-old woman with breast cancer. (a) Mammography shows heterogeneously dense breasts with multiple benign calcifications and no suspicious abnormalities. Coronal (b) and transverse (c) ABUS images demonstrate a 0.6-cm irregular hypoechoic mass in the left breast at the 1 o'clock position. The AI-CAD system automatically marks the lesion at coronal image.

agreement.

Multiple studies have shown improved AUC values and diagnostic accuracy with AI-CAD assistance, without compromising specificity or workflow efficiency (Table 1). The most substantial improvements have been observed among less experienced readers, suggesting that AI-CAD support helps narrow the performance gap between novice radiologists and expert radiologists. These findings indicate that the integration of AI-CAD into ABUS workflows enhances diagnostic reliability and reader confidence without sacrificing accuracy.

By assisting with lesion detection and standardizing interpretation, AI-CAD contributes to a more reliable and reproducible diagnostic process, particularly in women with dense breasts.

Support for Less-Experienced Radiologists

AI-CAD assists radiologists in identifying subtle or small hypoechoic lesions that are easily overlooked, particularly in dense or heterogeneous breast tissue, thereby minimizing the risk of false negatives and ensuring more comprehensive lesion detection. It also supports less-experienced readers in making appropriate management decisions by prompting the reclassification of suspicious lesions that might otherwise be categorized as benign, thus contributing to standardized diagnostic thresholds and improved clinical consistency

(12, 13). By providing visual cues for suspicious findings, AI-CAD reduces uncertainty in Breast Imaging Report and Data System (BI-RADS) categorization and increases both confidence and accuracy, which is especially beneficial in training environments and high-volume screening centers where inter-reader variability is a concern.

In South Korea, LuCAS-ABS (Monitor Corporation, South Korea) incorporates a variable detection threshold that allows users to adjust its operating mode between screening and diagnostic settings. The screening mode, optimized for novice readers, emphasizes higher sensitivity and displays a greater number of CAD marks, making it suitable for population-based screening settings, whereas the diagnostic mode is designed for experienced radiologists in general or tertiary hospitals, prioritizing higher specificity and presenting fewer CAD marks. This flexible, context-specific configuration enables optimized clinical application of AI-CAD according to reader experience and practice setting, thereby promoting both efficiency and accuracy across diverse clinical environments.

2. Key Considerations When Using AI-CAD

Risk of Increased False Positives

AI-CAD systems may misinterpret normal anatomic structures—such as Cooper’s ligaments,

Table 1. Diagnostic Performance in ABUS CAD Studies

Study	CAD use	Sensitivity	Specificity	AUC
Kwon et al. (10)	Without CAD	76.60%	88.00%	0.87
	With CAD	80.7~89.0%	92.3~98.3%	0.919
Yang et al. (12)	Without CAD	Novice: 67%, Expert: 93%	Novice: 58%, Expert: 63%	0.88
	With CAD	Novice: 88%, Expert: 94%	Novice: 57%, Expert: 63%	0.90
Jiang et al. (13)	Without CAD	62.10%	87.40%	0.828
	With CAD	61.50%	89.80%	0.848
van Zelst et al. (11)	Without CAD	73.7~78.9%	72.9~92.8%	0.77
	With CAD	78.9%~89.2%	71.4~92.8%	0.84

ABUS, automated breast ultrasound; CAD, computer-aided diagnosis; AUC, area under the receiver operating characteristic curve.

peri-areolar shadowing, ribs or skin lesions—as suspicious lesions (14). This can result in false-positive findings that lead to unnecessary recalls or biopsies, potentially increasing patient anxiety and healthcare costs. Radiologists should therefore

critically evaluate AI-CAD marked regions, integrating clinical context and other radiologic correlation before making management decisions.

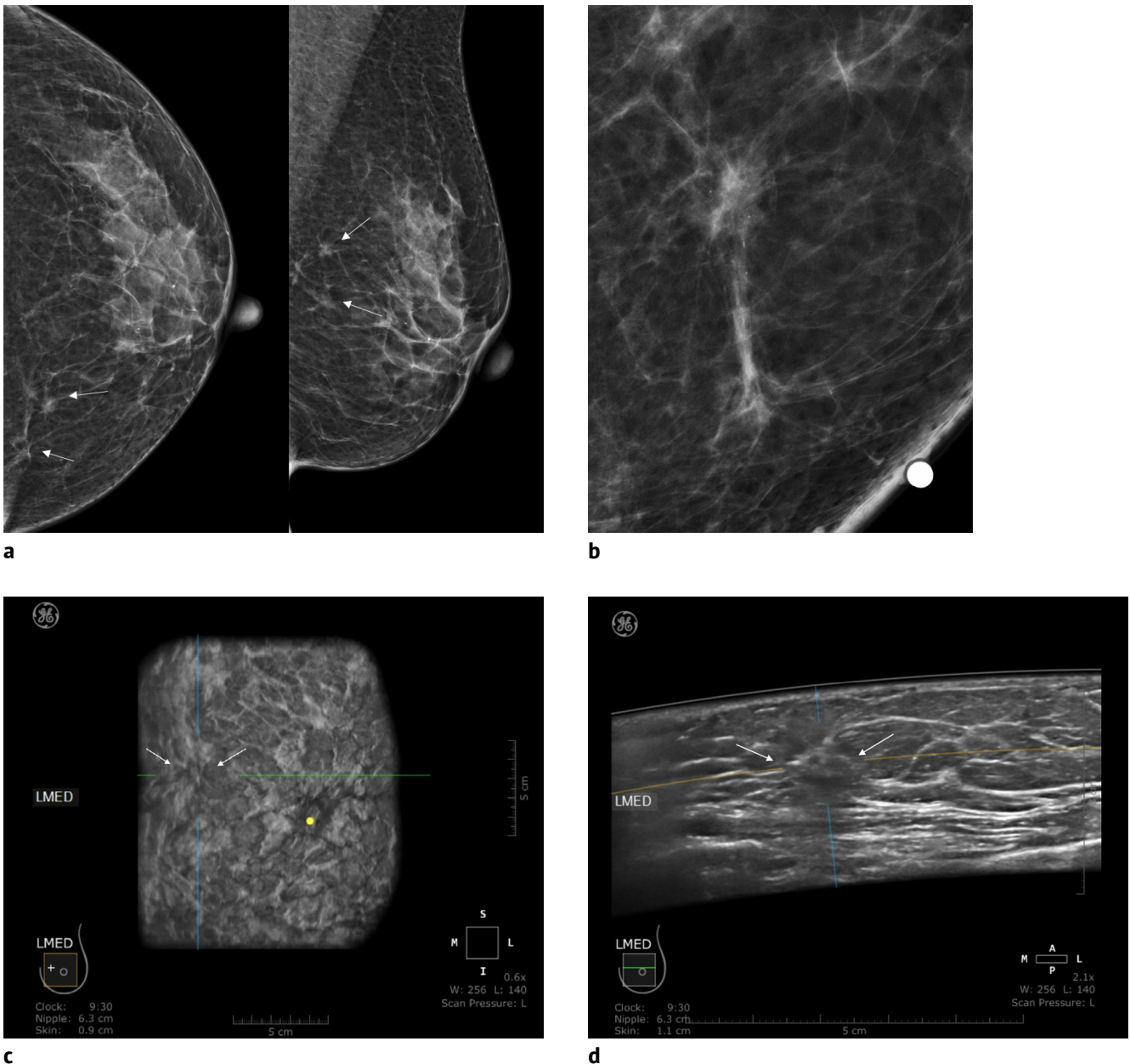


Fig. 2. Mammography and automated breast ultrasound (ABUS) images of a 54-year-old woman with invasive breast cancer. (a) Left mammography shows focal asymmetry in the inner breast (white arrows). (b) Magnification view reveals focal asymmetry containing suspicious microcalcifications. Coronal (c) and transverse (d) ABUS images demonstrate an ill-defined nonmass hypoechoic lesion without a retraction phenomenon at the left 9 o'clock position (white arrows). The AI-CAD system does not mark this lesion. US-guided core needle biopsy and subsequent surgery confirmed a 2.1-cm invasive carcinoma with associated ductal carcinoma in situ.

Risk of Increased False Negatives

Although AI algorithms exhibit high sensitivity, they remain susceptible to diagnostic error. Comprehensive recognition of the imaging characteristics of breast cancers that are overlooked by AI-CAD is imperative for enhancing diagnostic accuracy in ABUS interpretation. Kim et al. (15) reported that false-negative outcomes were more frequent in asymptomatic patients ($p < 0.001$) and were associated with the following ultrasonographic features: smaller lesion size ($p = 0.001$), posterior-third depth ($p = 0.002$), angular or indistinct margins ($p < 0.001$), and absence of architectural distortion ($p < 0.001$). To minimize oversight, AI-CAD outputs should always be interpreted in conjunction with the full volumetric dataset and coronal and sagittal reconstructions.

Limitations in Detecting Microcalcifications and Non-Mass Lesions

ABUS—and therefore ABUS-based AI-CAD—has inherent limitations in detecting microcalcifications or nonmass lesions. Because AI-CAD primarily analyzes morphologic and textural abnormalities, ductal carcinoma in situ (DCIS) or early pre-invasive diseases may be overlooked (Fig. 2). Kwon et al. (10) found that AI-CAD-negative cancers were less likely to show a retraction phenomenon in the coronal plane, likely due to difficulty defining margins of nonmass lesions (16). This finding underscores that AI-CAD in ABUS should complement, not replace, mammography—especially for detecting microcalcifications, subtle architectural distortions, and asymmetries. Therefore, concurrent interpretation of mammography and ABUS with AI-CAD remains essential for comprehensive breast cancer screening.

AI-CAD Training Data Bias

AI performance is strongly influenced by the characteristics of its training data. Models trained predominantly on Western populations may exhibit reduced accuracy when applied to Asian women, whose breast density, morphology, and imaging characteristics differ. To overcome this limitation, fine-tuning and retraining AI models using Asian-specific and multi-institutional datasets are strongly recommended. LuCAS-ABS (Monitor Corporation, South Korea) was trained on an extensive dataset of Korean breast cancer cases, a population characterized by smaller and denser breasts compared with Western women. This training approach enhances model generalizability and ensures equitable diagnostic performance across diverse patient populations.

Conclusion

AI-CAD in ABUS enhances workflow efficiency, diagnostic accuracy, and inter-reader consistency, while providing educational value for less-experienced radiologists. However, challenges remain, including false-positive and false-negative detections, potential bias related to training data, and inherent limitations in detecting microcalcifications and non-mass lesions. When appropriately validated and effectively integrated into clinical workflows, AI-CAD can serve as a reliable adjunct to radiologists, facilitating standardized, efficient, and high-quality breast cancer screening, particularly in women with dense breasts.

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자동 유방 초음파에 대한 인공지능 기반 컴퓨터 보조 진단의 임상적 적용

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자동 유방 초음파(ABUS)는 기존 유방 초음파의 장점을 유지하면서 검사자 의존성과 재현성 한계를 보완하기 위해 개발되었다. 방사선사가 표준화된 방식으로 촬영한 영상을 영상의학과 전문의가 별도 시간에 판독할 수 있어 효율적이며, 관상면 제공과 넓은 시야 확보를 통해 병변 평가의 정확도를 높여 유방촬영술의 보완적 선별 도구로 유용하다. 그러나 대용량 영상으로 판독 시간이 증가하고 판독자 간 변이가 발생할 수 있다. 이를 보완하기 위해 인공지능 기반 컴퓨터 보조 진단 (artificial intelligence-based computer-aided diagnosis (AI-CAD)) 이 도입되었으며, 대규모 영상을 신속 분석해 의심 병변을 제시함으로써 판독 효율성과 일관성을 향상시키는 장점이 있다.

본 종설에서는 ABUS 판독에 있어 AI-CAD 적용에 관한 여러 문헌들을 고찰하고, 임상적인 이점, 적용 시 고려 사항, 그리고 잠재적 한계점에 대해 논의하고자 한다.

Index words: Breast; Automated breast ultrasound; Artificial intelligence;
Computer-aided diagnosis

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