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Automated breast volume scanner (ABVS) in breast cancer – a review

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Summary

The early detection of breast cancer is essential for its timely diagnosis and treatment. Many imaging modalities are continually being developed to screen and diagnose breast cancer at an early stage. Especially, ultrasound (US) is one of useful diagnostic tools to distinguish benign from malignant masses of the breast. However, the US image has some limitations, such as low resolution and low contrast, speckle noise, and blurry edges between various organs. Recent technological advancements in the area resulted in development of automated breast volume scanner (ABVS) that could increase the diagnostic confidence for a physician and provide a possible solution to improve the positive predictive value of breast biopsy. The purpose of the present review article was to explore the advantages and technical advancements of ABVS for diagnosing breast cancer patients.

Key words: Breast cancer; ABVS; Ultrasound; Automation; Retraction; Ductal carcinoma.

Introduction

Breast cancer is one of the most widespread causes of death in women [1]. According to current research, cancer is diagnosed in approximately one in every ten women. The reliable and timely diagnosis of breast cancer can have a significant effect on treatment.

There are diverse diagnostic techniques for detecting and categorising breast cancer, for example, biopsy, X-ray mammography, ultrasound (US), and magnetic resonance imaging (MRI). The current gold standard in breast cancer diagnosis is biopsy. Studies show that 68–87% of biopsies yield negative results [2]. In addition, this is an invasive technique that necessitates surgical removal of tissue samples from the patient, and it is a time consuming process, requiring days to weeks to obtain results.

The use of advanced technology in any field is essential for excellence. Nowadays, automation is one of the most exploited techniques for achieving better efficiency without any wastage of time and resources as well. Ultrasonography is one of the most handy and portable tool for detection of breast lesions. It is the method of choice for the detection of small breast lesions (diameter < two cm) as they appear negative on diagnostic techniques like clinical palpation or X-ray mammography [3-5]. It is beneficial over other techniques in terms of portability, speed, and economy. Handheld applicability of ultrasonography gives user an ease of use. Furthermore, high-speed detection of ultrasonography allows real time imaging. Thirdly, being inexpensive it is very affordable to patients. These are the prime reasons which are responsible for the wide applicability of ultrasonography in clinical settings till date. However, besides so many advantages, the main cons of conventional US are its dependency on operator, lack of efficiency in diagnosing malignancy and in ductal carcinoma in situ (DCIS). The ultimate solution to solve the above problems of conventional US has been sought via the development of a system for automated US scanning of the breast [6]. Moreover, in ultrasonography, automation is the latest innovation in the field of cancer diagnostics. Therefore, the present review article aimed to report important advancements in ultrasonography with special reference to breast carcinoma. The review will focus on major contributions by (automated breast volume scanner (ABVS) in breast tumor diagnosis with special reference to deep seated- tumors like DCIS.

ABVS

ABVS is one of the latest technological breakthroughs that have been proposed as a suitable alternative for breast cancer screening [7]. It is a safe, painless, radiation-free, and non-invasive technology. It is a three-dimensional US technology that is specifically developed for whole breast imaging and allows for images of high-resolution to be

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produced [8]. It has also been referred to in the literature as automated whole-breast ultrasound (AWBS), and sonographic tomography [9]. ABVS is a three-dimensional volume imaging system that is able to provide data from the entire breast. It automatically moves in a straight line while the operator applies pressure. US scans are performed in three directions (anteroposterior, lateral, and medial), with the addition of further inferior and superior scans, if necessary, to cover the whole breast. In addition, the system automatically reconstructs whole breast images from the coronal and sagittal views, allowing multiplanar display and true US tomography of the breast [10-12]. There are some advantages in the current high-resolution automated scanner: 1) better demonstration of the breast anatomy, 2) proper orientation and documentation of lesions detected, and therefore better reproducibility and good for follow-up studies, 3) volumetric data provide potential information for computer-aided detection and diagnosis (CAD) of breast lesions, 4) simple to use without a long period of training, which is good for technologists, and 5) time efficiency for the radiologists.

Advantages of ultrasonography over other modalities

X-ray mammography is the most widely used method for the detection of breast cancer. X-ray mammography is a non-invasive technique that can distinguish breast cancer from small lesions, as well as masses palpated during physical examinations, and DCIS [13]. However, X-ray mammography has a 10% rate of false negative results [14]. While a false positive rate in X-ray mammography varied from 8–21% [15]. The development of cancer sometimes goes undetected because of inadequate sensitivity and limited resolution of the technique. On the other hand, MRI is used for women at high-risk for breast cancer. In addition, many studies have demonstrated that MRI can be used as an additional technique to determine the extent of cancer using gadolinium enhancement, once breast cancer has been detected. Invasive breast cancers show better images after injection of contrast-enhanced MRI gadolinium. Some clinicians use it to determine the stage of cancer. Although the sensitivity of MRI is high, the specificity is moderate to low, and the technique is expensive [16].

Conventional US based on two-dimensional imaging has been used as an additional characterisation technique after X-ray mammography. US diagnosis aims at evaluating palpable masses and is considered to supplement mammography. US has certain advantages over X-ray mammography: it is more sensitive than mammography for dense breast tissue and it is recognised as the most readily accepted tool in differentiating a simple cyst from a solid lesion [17-20]. Breast US can be used to detect a cystic mass as small as one to two mm with 100% specificity [21]. Furthermore, quantitative US (QUS), such as the broadband US attenuation (BUA) method, can provide not only structural/volume information, but also information regarding tissue content [22].

Studies confirming efficacy of ABVS

A study in recent past on ABVS was conducted to evaluate its ability to detect and classify breast lesions according to the Breast Imaging Reporting and Data System (BI-RADS) [7]. Thirty-five women who had unclear findings in breast diagnosis performed through palpation, sonography, or mammography were selected and received ABVS. Five radiologists independently evaluated the ABVS images and classified them according to BI-RADS. All breast cancers were found with the AVUS by all examiners and correctly classified in the BI-RADS. In this study, ABUS allowed detection of solid and cystic lesions and their BI-RADS classification with a high reliability.

Another recent study on ABVS was conducted to determine the accuracy of measuring preoperative cancer extent [23]. This retrospective study assessed 40 patients with histopathologically confirmed breast cancer who underwent ABVS on the day prior to surgery. The age range of patients was 31-76 years. No discrepancy was found in comparison of the tumor extent between ABVS and the histological examination, as ABVS enabled visualization of the breast carcinomas in all patients. The accuracy of determination of the tumor extent with a deviation in length of less than two cm was 98% by ABVS. In another study, 40 patients aged 23-68 years underwent ABVS in the upper-outer, lower-outer, lower-inner, and upper-inner breast regions. The researchers compared ABVS to handheld ultrasound (HHUS) and observed total of 61 lesions both by HHUS and by ABVS. Moreover, the present authors have also studied efficacy of ABVS over HHUS in their lab. They scanned the breasts of 300 patients using the ABVS system as well as conventional US. The ABVS modality significantly surpassed conventional US by detecting significantly higher number of lesions, by detecting retraction phenomenon for malignancy, and by detecting DCIS via confirming the presence of micro-calcifications [24].

ABVS has also been compared to MRI in a retrospective analysis [25]. Forty-one women diagnosed with breast cancer had preoperative staging using ABVS. Both imaging techniques were compared for accuracy to pathologic truth. ABVS accurately staged breast cancer preoperatively in 68% of cases, while MRI only in 54% of cases.

Conclusions

The aforementioned studies and literature confirm that ABVS is a promising new technology that might be useful for screening for breast cancer in women with dense breast tissue. It can potentially help in the preoperative evaluation of breast cancer, including deep-seated tumors like DCIS,

and might replace standard HHUS.

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