Computer aided detection in automated breast ultrasound screening: a pilot study

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Aims and objectives

Mammography screening programs have been introduced successfully to reduce breast cancer mortality in women (1,2). However, the sensitivity of mammography in women with dense breasts is low. Therefore, several breast cancer surveillance programs offer additional breast ultrasound screening to women with dense breasts. These supplemental ultrasound screening programs increase the yield of breast cancer with 0.19 to 0.52 percent (3-7).

Threedimensional automated breast ultrasound (ABUS) system are designed for breast ultrasound screening. ABUS systems acquire 154mm x 168mm x 60mm large B-mode ultrasound volumes with a 14L5BV 5-14MHz automatically driven linear array transducer. The width of the transducer is usually not sufficient to ensure coverage of the entire breast. Therefore, multiple volumes (two to five) are acquired per breast depending on the size of the breasts. This acquisition protocol is standardized and can be performed by non-radiologists. After the acquisition, the images are reconstructed by a dedicated workstation into a transverse, sagittal and coronal plane. Hereafter, the radiologist can evaluate the ABUS volumes of the entire breast. After the evaluation, the ABUS images can be stored in an image archive and retrieved from the archive to compare new ABUS scans with relevant priors.

Breast cancer screening with ABUS is challenging for radiologists. The reading time is relatively long due to multiple large image volumes. Consequently, some breast lesions may easily be overlooked. Computer aided detection (CADe) systems can help radiologists in breast cancer screening (8). While recent studies in CADe development show promising results (9,10), it remains to be determined whether CADe software can aid radiologists in breast cancer screening with ABUS.

This study evaluates whether computer aided detection (CADe) aids radiologists in cancer detection.
Methods and materials

The need for informed consent was waived by a local ethics committee (IRB).

Image data set

ABUS scans (Siemens s2000 ABVS, Erlangen, Germany) from 89 different patients were randomly selected from a large image archive. These ABUS images were obtained at three clinical sites and were derived from clinically indicated examinations. For each patient one single ABUS scan was selected for this dataset. The ABUS cases were labelled as 'normal' (n=1064), 'benign' (n=260) or 'malignant' (n=100) based on histological verification or after follow up. The malignant cases were confirmed by a pathologist after histological evaluation of the biopsy specimen and, when available, confirmed by evaluation of the surgical specimen. We randomly selected 19 scans containing malignant lesions, 30 scans containing benign lesions and 40 scans that were labelled as normal.

CADe software

All ABUS scans were processed with dedicated CAD software (Qview Medical Inc., Los Altos, Ca, USA), generating suspicious region markers that are displayed in an intelligent minimum intensity projection (MinIP) image (figure 1). The MinIP is a 2D image of the breast tissue only after segmenting and removing of the chest wall. The MinIP highlights hypoechoic regions in the ABUS volume by displaying "dark spots". We also projected CADe marks on the MinIP of the CADe regions with the highest probability at a threshold of 1 false positive (FP) CADe marks per ABUS volume. The multiplanar hanging automatically snaps to the corresponding region in the ABUS volume after clicking on the dark spots or CADe marks (figure 2). The sensitivity of the CADe system was 84% at a threshold of 1 FP per ABUS volume.

Reading sessions

After a training session, five radiologists (three dedicated breast radiologists with extensive experience with ABUS and two fifth year radiology residents without ABUS experience) were instructed to mark suspicious findings, classifying them on a semi-continuous likelihood scale from 0-100. All readers first read 45 scans without CADe-support and 44 scans with CADe-support, and in a second session reading modes were swapped. The ABUS scans were presented to the readers during both reading session in a random order. We advised the readers to spend no more than one minute per scan, which is comparable to the evaluation time of ABUS in the screening practice (7). The reading sessions were at least five weeks apart to minimize any memory effect.
**Statistical analysis**

Multi-case-multi-reader ROC analysis was used to evaluate reader performance with the DBM-MRMC statistical software package (11-13) by comparing area under the curves (AUC) of CADe-unaided reading and CADe-aided reading. Results are considered significant if p < 0.05.
**Fig. 1:** The coronal reconstructed ABUS image on the left show a single slice of the ABUS volume. The panel on the right shows the Minimum Intensity Projection (MinIP). The dark regions on the MinIP can be evaluated by clicking on them. Consequently, the multiplanar hanging will snap to the corresponding region. On the MinIP there are CADe marks projected over the CADe regions with the highest probability. In this particular case the pink CADe mark signals out a region that shows a small indistinct hypoechoic lesion with a spiculation and retraction pattern in the coronal plane. Histological evaluation of this lesions showed a complex sclerosing lesion.

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Fig. 2: The dedicated automated breast ultrasound workstation by Qview Medical Inc (Los ALtos, Ca, USA). The left vertical plane is the sagittal reconstruction. The horizontal plane on top is the transverse ABUS data. The panel in the middle shows the coronal reconstructions and to the right is the Minimum Intensity projection image with overlaying CADe marks. The readers evaluated each scan in this hanging protocol during the CADe aided reading session. The CADe unaided reading session was performed in the same workstation but the hanging protocol did not include the MinIP or the overlaying CADe marks.

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Results

Almost all readers (four out of five) detected more cancers with CADe software support than reading the ABUS dataset without CADe support. The averaged performance of all readers measured by the area under the curve (AUC) for reading ABUS unaided was 0.76. The AUC for CADe aided reading was significantly higher at 0.83 (p=0.005) (figure 3). Three particular cancers were missed by all readers in nine out of ten reading sessions. The same three cancers were not detected by CADe at a threshold of 1 FP per ABUS volume.
Fig. 3: Receiver Operating Characteristics curve of the average performance of all readers. The areas under the curve improved significantly from 0.76-0.83 ($p = 0.005$) after reading automated breast ultrasound scans with CADe support. Results are considered significant if $p < 0.05$.

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Conclusion

Computer aided detection has the potential to improve the accuracy of breast cancer detection by radiologists in ABUS.
Personal information

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Fig. 4: Visit our ASSURE project website at www.assure-project.eu

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References


