

# Automated Breast Volume Scanning 3D Ultrasound of the Breast

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Figure 1. The Siemens ACUSON S2000 Automated Breast Volume Scanner.



Reducing subjectivity and operator-dependent bias from ultrasound, Automated Breast Volume Scanning (ABVS), or 3D ultrasound, opens the door to new applications in mammary diagnostics and beyond. With its recent acquisition of a Siemens ACUSON S2000™ Automated Breast Volume Scanner (ABVS), the radiology department of the Jeroen Bosch Ziekenhuis (JBZ) in 's-Hertogenbosch, The Netherlands, is the first institution to use this new system in The Netherlands. A second system became operational at the St. Radboud University Nijmegen Medical Centre (RUNMC) two months later. First results are very promising, according to radiologists Matthieu Rutten (JBZ) and Roel Mus (RUNMC).

Performing a “hand held” 2D ultrasound is inextricably dependent on the individual manipulating the transducer. During real-time image interpretation, tissue anomalies may occasionally be overlooked. The shortage of experienced sonographers and the time required for thorough examinations are obstacles that have thus far limited the application of hand held ultrasound in breast diagnostics, especially screening. 2D ultrasound is mostly used as an additional imaging modality following mammography.

The arrival of automated 3D ultrasound has the potential to change that. Pre-programmed trajectories ensure that images of every part of the breast are generated by scanning the entire breast. The actual procedure is performed by a radiology technician or sonographer. The ensuing data are evaluated by a radiologist at a 3D workstation by analyzing the images of the breast in any desired direction.

Presently a number of systems are available. An approach that reminds us of technology from the 1970s and 1980s is a system that requires patients in a prone position, breasts submerged in a tub filled with warm water. Other systems use a less known imaging approach, in

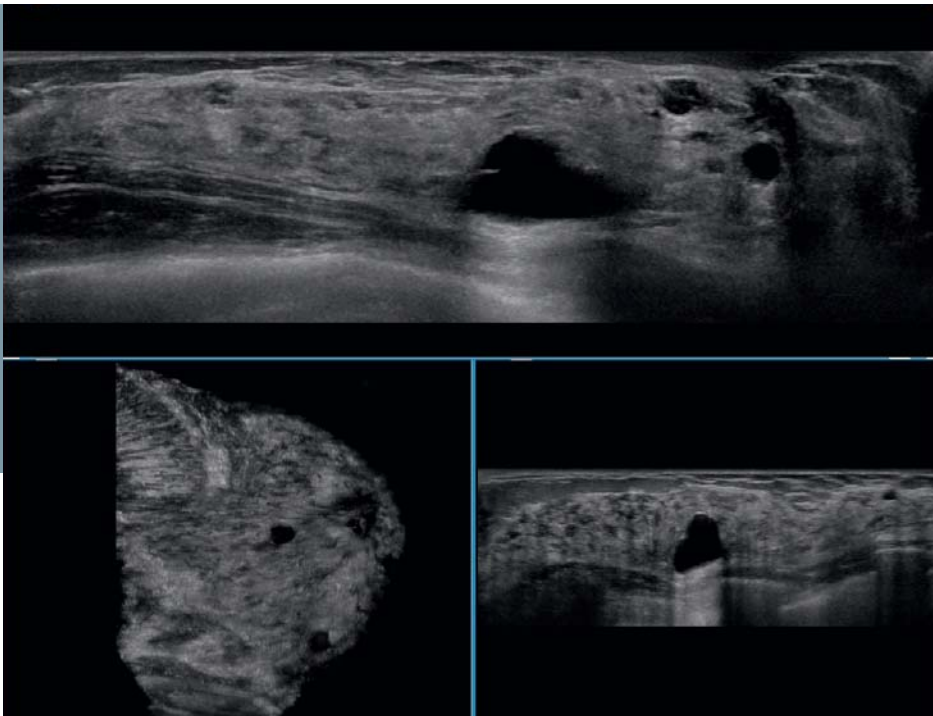


Figure 3. 3-in-1 hanging protocol of a 3D ultrasound examination of the breast. Above: transverse; bottom left: coronal; bottom right: sagittal.

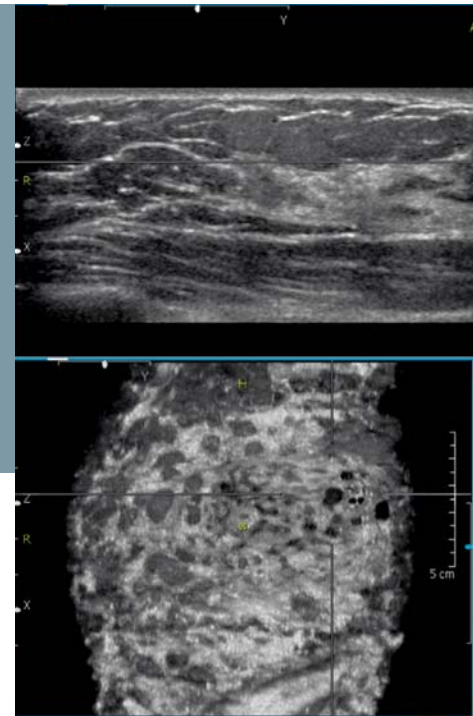


Figure 4. Automated Breast Volume Scan of a cyst. Location indicated inside marker, with distance to skin and nipple. Above: transverse; bottom left: coronal; bottom right: sagittal.

which patients in a supine position have their breasts scanned via a swiveling arm-mounted transducer that follows a number of pre-programmed trajectories (AP, lateral and medial). In the latter category, the Siemens ACUSON S2000 ABVS (Figure 1) is the most advanced system currently available commercially.

The system is equipped with a 5-14 MHz broadband transducer featuring Harmonic Imaging, and acquires 3D images of the breast in approximately 70 seconds. The entire examination of both breasts takes about 10 minutes.



Figure 2. Scan configuration.

## Advantages of ABVS

The ABVS technique reduces the subjectivity of ultrasound and makes it easier to verify results and compare them with mammographic and 3D-MRI findings, transforming ultrasound into a tool for double reading and improved diagnostic precision.

An additional advantage of 3D ultrasound is the unique way in which the anatomy of the breast is rendered through a reconstruction of three orthogonal planes: transverse, sagittal and coronal (Figures 3 and 4). This third orientation allows slice-by-slice evaluation of the anatomy, from the skin down to the thoracic wall, a view currently not available using conventional 2D ultrasound. At the ABVS Workplace, the clinician can later adjust slice thicknesses down to a minimum of 0.5 mm. The coronal orientation turns out to be particularly well-suited for depicting anomalies in the make-up of glandular breast tissue. Small tumors with spiculae are best rendered in a coronal orientation (Figure 5).

Lesion position is indicated on a coronally-oriented marker, and the distance to the skin and nipple is indicated in centimeters, which allows for easier and more insightful preoperative surgical planning.

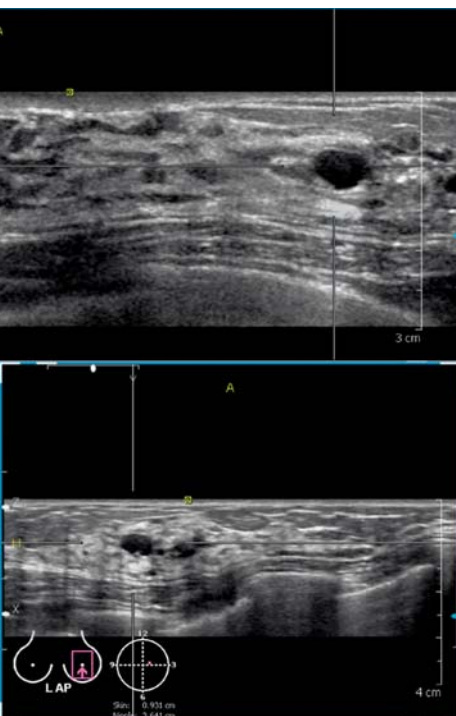
A major advantage is the optional storage of the full set of images which offers a reliable baseline for future comparison at the patient's next checkup. Additionally, batch evaluation of examination results by the radiologist can take place anytime, similar to the current post-processing of mammograms from the "Bevolkingsonderzoek Borstkanker" (breast cancer screening program) in the Netherlands.

## Learning curve

As with all medical imaging, first-time users will have to be trained to use the technology, for example, how to maintain sufficient contact between the transducer and the breast during the examination. The pressure needed to maintain contact is generally well below the pain threshold, but can still be somewhat uncomfortable for the patient.

The interpretation of the images is also subject to a learning curve (Skaane et al., ECR 2010). Reporting a 3D ultrasound examination can take from 5 to 35 minutes, dependent upon experience and case complexity. Cross-correlation between the multiplanar reconstructions helps to accelerate the evaluation process of the 2,000 to 2,500 images. This is an acquired skill, comparable to the





shown in 3 directions. Bottom right: lesion  
skin and nipple shown underneath.  
right: sagittal.

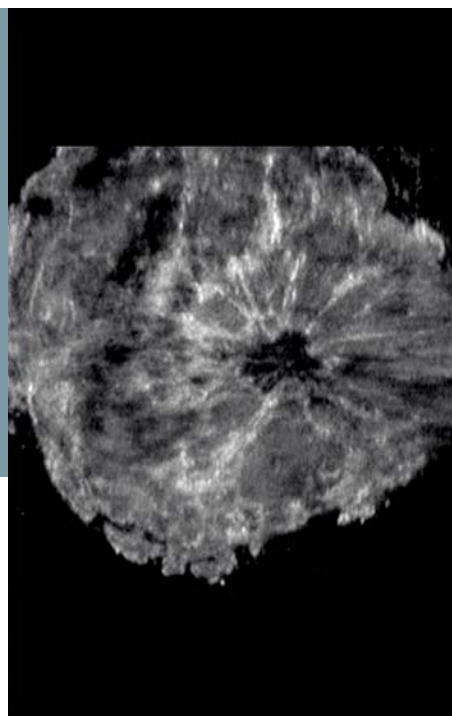
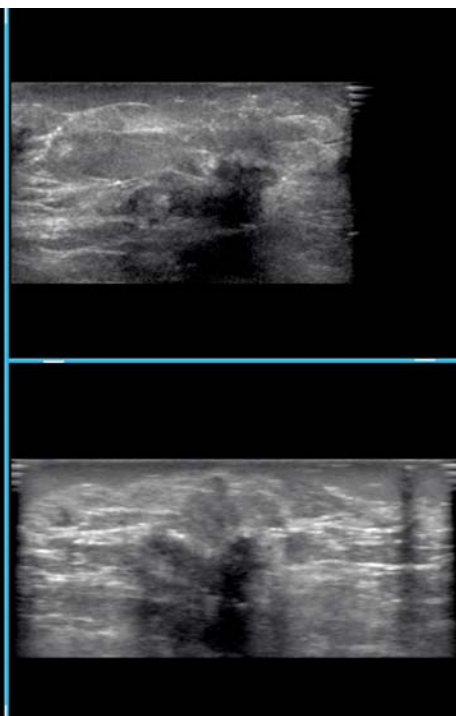


Figure 5. Post-lumpectomy exam of a specimen for verification. The coronal aspect (left) clearly shows the hypoechogenic tumor, bounded by spiculae. Above right: transverse; bottom right: sagittal.



evaluation of the results of a 3D MRI breast examination. As the A-P diameter of the breast is much smaller than the L-R or craniocaudal diameter, the entire set of data can be worked through much more quickly with the coronal view. First experiences with the 3D ultrasound system show that evaluation of the generated images takes 2-4 minutes per breast, much faster than hand held ultrasound.

## Is ultrasound a useful addition to mammography screening?

Interest in a combined mammography/ultrasound screening protocol was raised by the results of the American College of Radiology Imaging Network (ACRIN) 6666 study (Berg et al., JAMA 2008), which showed that combined use of the two modalities allows more tumors to be traced in women with a high risk of breast cancer and a dense glandular breast tissue structure. The study not only showed that over half of the women aged under 50 have more than 50% glandular tissue (in women over 50 this number is 30%), but also that the sensitivity of mammography with these women levels out at 30-48%. Berg et al. (JAMA 2008) showed that the addition of

ultrasound to mammography increased tumor detection sensitivity to 77.5%. Their proposal is to introduce ultrasound as a supplementary screening modality.

A drawback of the revised examination protocol is the extra time required. The ACRIN report states that the average examination time for a bilateral ultrasound breast examination is 19 minutes, which does not include comparison with earlier examinations and reporting. At a rough estimate, 35% of the population of patients with more than 50% glandular tissue will need additional ultrasound examinations. This will mean a significant increase in workload and hence a lack of manpower. Automation of procedures, however, means that the actual examination can be performed by radiological technicians, and data acquisition and reporting can be performed separately, both in place and time.

Partly as a result of the outcome of the ACRIN 6666 study in October 2009, the American State of Connecticut has passed a bill that grants women the right to be informed on the amount of glandular tissue in their breast and its implications for their screening. It is expected that this will strongly increase interest in breast ultrasound, with the rest of the world soon to follow this lead.



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## Scientific research

The St. Radboud University Nijmegen Medical Centre and the Jeroen Bosch Hospital are about to begin further clinical research using the ACUSON S2000 ABVS.

Although the first results are promising, much research still needs to be done regarding the value of 3D ultrasound. Multiple studies have already been set up in Germany, the United States of America, Japan and the Netherlands (RUNMC and JBZ). These studies specifically address the sensitivity, specificity and positive predictive value of 3D ultrasound compared with 2D ultrasound and MRI.

Improved specificity could help reduce the number of biopsies performed. However, the added value of 3D ultrasound seems to be lesion detection rather than lesion characterization. Automated volume ultrasound will probably make it easier to find smaller tumors (3-4 mm). The potential to review the 3D digital data sets of ultrasound images using a computer-aided detection (CAD) system should be expanded in the future.

Women with an average breast cancer risk, i.e. a 10 to 20% lifetime risk of developing the disease, could probably gain the most from automated ultrasound screening for breast cancer. Presently in Europe and the United States, MRI is recommended as an additional screening modality for women with a high risk (20% or up) of breast cancer. Women with an intermediate breast cancer risk do not qualify for anything other than standard mammography, but they may also have a

dense glandular breast tissue structure that negatively impacts the precision of mammographic examination. Women with more than 75% glandular breast tissue have a 4 to 5 times higher risk of breast cancer than women with little to no glandular tissue in their breasts. This results in a higher percentage of interval carcinomas and a poorer prognosis for any clinically diagnosed tumors.

Especially for young women with a BRCA1 or BRCA2 gene mutation and dense breasts, additional examinations through ultrasound could well be much more reliable than conventional mammography, with the added advantage that no radiation is used. Presently this category of patients is screened according to a protocol involving a yearly mammogram and an MRI of the breasts.

Using the ACUSON S2000 ABVS, the radiology departments of the Radboud University Nijmegen Medical Centre (Roel Mus, Henkjan Huisman, Nico Karssemeijer) and the Jeroen Bosch Hospital in 's-Hertogenbosch (Matthieu Rutten, Mathijn de Jong, Ivo Dubelaar, Thomas Fassaert) will this fall start a clinical study among women who carry a BRCA gene mutation. In this study the current protocol (combined yearly mammography + MRI) will be compared with an alternative protocol (biannual ABVS + yearly mammography + MRI). Also the results of automated breast volume ultrasound and mammography will be compared.

We hypothesize that the use of automated breast volume scanning will detect more tumors than mammography,

and that the incidence of interval carcinomas will decrease as the ABVS examination will take place every six months.

In regular screening, the distinction between a cyst and a hypoechogenic fibroadenoma is of less importance (both being BI-RADS 2, i.e. benign). However, in examining BRCA gene carriers this distinction is very important as the growth rate of tumors in this group is much higher than in "regular" patients. The fast-growing tumor pushes the surrounding tissue away, leaving little time for spicula-like ingrowth. Hence, BRCA tumors are often characterized by an echographically clear, "benign" delineability.

The entire study will take approximately two years. By that time we expect to have gathered sufficient data to assess the role of automated breast volume scanning in detecting breast cancer.

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