Automated Breast Volume Scanning: Technique and artefacts

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Learning objectives

Automated Breast Volume Scanning (ABVS) is a new promising 3D Ultrasound (3D-US) technique in breast imaging. Technique and artefacts are explained and illustrated.
Background

Ultrasonography (US) is an established technique in breast imaging. The ABVS 3D technique is a new application using a high frequency broadband transducer. In addition to conventional handheld 2D US (HH-US), it produces reproducible operator independent 3D data sets, readily available for review, postprocessing and second reading.
Automated acquisition of volume scans of the complete breast are performed with 3D ultrasound. For this purpose we used an ACUSON S2000 from Siemens with a 5-14 MHz broadband transducer (using Tissue Harmonic Imaging) mounted on a flexible arm. (figure 1 & 2)

**Aquisition**

With selection of cup size, optimized presets are automatically loaded. Gain and depth can manually be adjusted. Scan depth is limited to 6 cm because of loss of detail with increasing depth (figure 3). The transducer is positioned on the breast, perpendicular to the craniocaudal axis of the patient. This is necessary for localization of findings in clock / quadrant fashion. After the transducer is locked in place, extra mechanical compression can be applied to optimize contact with the breast and to compress the breast tissue, to gain an optimal field of view and resolution. With the push of a button, scanning commences. On each obtained data set, nipple position is marked for reference.

Depending on breast size, form and consistency, 3 or more scans are necessary to completely cover the breast. From skin to thoracic wall, from the anterior axillary line to the sternum, and from the clavicle to the inframammary skinfold the breast is scanned. Each data set comprises of 318 consecutive axial images from which other view planes are reconstructed.

Standard AP, lateral and medial scan can be followed by additional superior and inferior scans in cup sizes C and larger for full coverage. Also after surgery, radiation therapy or prosthesis, breasts are more firm / have a less manipulative form, and more scan sets have to be added for complete coverage. Automated scanning takes approximately 70 seconds per scan field.

**Data processing**

Acquired data is automatically processed and a coronal and sagittal data set are obtained. In acquisition, completeness of the obtained scans can be verified. The images are send to a dedicated workstation for post processing (figure 4). Data is standard presented in transversal, sagittal and coronal plane (figure 5). The coronal plane is new in breast ultrasound, and quite similar to the surgeons view during surgery, giving surgeons an easy localizer for pre-operative planning. 3D US coronal images can be compared to MRI coronal imaging (although MRI acquisition is performed in prone position and uncompressed). Findings can be simultaneously evaluated in 3
planes, which facilitates the detection and discrimination of breast lesions. Furthermore, radial, anti-radial orientation and reconstruction in any desired plane is possible. With a dedicated work station it is also possible to zoom, pan, measure, invert and take snapshots. A comprehensive BIRADS report can be produced. Depending on number of series, breast tissue and number of lesions, evaluation of both breasts is done in 7 to 20 minutes.

**Artefacts**

With this new 3D ultrasound technique, new or more pronounced artefacts are identified.

**Probe motion artefact** (figure 6 & 7).

For an optimal field of view and resolution, the breast is compressed between the transducer and the thoracic wall. However, compression may prevent the transducer from smoothly sliding over the breast surface, the transducer moves in a jerking motion. Especially in the sagittal reconstructions, this jerking motion artefacts can be seen. Smooth longitudinal tissue lines and interfaces are depicted as stuttering lines. This effect can also be produced if to little lotion/gel is applied to the breast, increasing skin resistance and producing the same jerking motion of the transducer.

**Skip artefact** (figure 8).

When the compressed breast encounters more superficially located round or oval lesions (e.g., cysts) of sufficient size, the lesion may jump away from off the transducer or the transducer may glide off the lesion. This also happens in conventional handheld 2D ultrasound. With automatic acquisition however, reconstruction in multiplanar views is possible because of standard acquisition method and transducer speed, plane as consecutive slices. When the transducer slides of a lesion, thereby moving faster than computed, a small area (or slice) is not taken in account in the construction of the data set. As a result, a part of the underling lesion, and all tissue at the same height/level will not be constructed in the data set. A cut off sign of the lesion and other tissue on this same level will occur.

**Contact artefact** (figure 9)

When contact with the skin is suboptimal, an acoustic shadow is commonly seen. Also possible is a reverberation artifact produced by a small air pocket between transducer and the skin, producing superficially located alternating black (hypoechoic) and white (hyperechoic) bands in axial and sagittal planes. Coronal reconstructions can show an
acoustic shadow in the reconstructed images on a single image, mimicking a lesion or scar tissue. When the first few images close to the skin are examined, the artifact area is alternating hypo and hyperechoic, conform the axial and sagittal planes. (figure 10)
Fig. 0: 1. Siemens ACUSON S2000 Automated breast volume scanner.

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Fig. 0: 2. ABVS transducer module positioned on the patient. In three or more caudocranial scan sweeps, the complete breast is scanned.

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**Fig. 2:** 3. Coronal images. Scrolling through the images, notice the progressive loss in detail of tissue as we move deeper in to the breast, further away from the transducer.

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Fig. 0: 4. Standard setup of the workstation. Axial (above), coronal (below left) and sagittal (below right) data sets are shown. Other hangings are also selectable. One can just see the localizer depicted near the midline, on the bottom of the screen, showing not only the clock position of a selected breast area or lesion, but also the calculated distance of the structure to the skin and nipple.

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Fig. 3: 5. Video of coronal images of the right breast. The difference between fat and glandular tissue is evident. Also note the stellate lesion in the upper lateral quadrant (11-12 o’clock); architectural distortion, desmoplastic reaction and spiculated growth pattern are nicely shown on coronal images. The blue square represents the location of the nipple throughout the coronal scan for reference.

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**Fig. 0:** 6. Subtle probe motion artefact. Note the hyperechoic pleural line, which should be depicted as a smooth line. In the breast tissue also, the jerking motion of the transducer can be seen.

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**Fig. 0**: 7. Severe probe motion artefacts. Axial (above), coronal (left corner) and sagittal (right corner) images of the same breast. Note the jerking tissue lines on the coronal (left side) and sagittal images.

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Fig. 0: 8. Skip artefact. Coronal (left) and sagittal (right) images of the same breast area. Note the cut off appearance of the cyst (cranial aspect on the coronal image, left side on sagittal image).

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**Fig. 0:** 9. Contact artefacts on the left and right side of the axial scan field (upper half of the image). The large area on the left is easily recognizable. On the right side of the data set however, the small artifact might cause the reader some trouble on the sagittal (below right; left side of the sagittal image) or especially the coronal (below left; right upper corner of the coronal image) images. (see also the video of coronal images marked as 'Fig 10' below)

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Fig. 1: 10. Coronal images of the contact artefact (right upper corner of the images). Note the change in echo reflection when going through the data set. Alternating hypoechoic and hyperechoic presentation of the artifact area, as result of reverberation.

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Conclusion

Automated Breast Volume Scanning (ABVS) or 3D ultrasound is a promising new technique in breast imaging.
References

Suggested reading in reversed chronologic order.


