Original Investigation

Diagnostic Performance of Automated Breast Volume Scanning (ABVS) Compared to Handheld Ultrasonography With Breast MRI as the Gold Standard

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Rationale and Objectives: This study aimed to compare the diagnostic value of automated breast volume scanning (ABVS) to that of handheld ultrasonography (HHUS) using breast magnetic resonance imaging (MRI) as the gold standard.

Materials and Methods: Twenty-eight patients with 39 examined breasts with at least one lesion visible in breast MRI underwent HHUS and ABVS. Detection rate, localization, maximum diameter, and Breast Imaging Reporting and Data System classification were compared. Sensitivity, specificity, diagnostic accuracy, positive predictive value, and negative predictive value were calculated for HHUS and ABVS. Lesion localization and maximum diameters based on HHUS and ABVS were compared to size measurement in MRI. Breast Imaging Reporting and Data System categories based on each method were compared to the MRI diagnosis (malignant or benign) or, if available (21 cases), with the histologic diagnosis.

Results: MRI detected 72 lesions, ABVS 59 lesions, and HHUS 54 lesions. Malignancy was proven histopathologically in 15 cases. There was no significant difference between ABVS and HHUS in terms of sensitivity (93.3% vs. 100%), specificity (83.3% vs. 83.3%), diagnostic accuracy (87.2% vs. 89.7%), positive predictive value (77.8% vs. 78.9%), and negative predictive value (95.2% vs. 100%). Agreement regarding lesion localization (same quadrant) was 94.3% for ABVS and MRI and 91.2% for HHUS and MRI. Lesion size compared to MRI lesion size was assessed correctly (+/– 3 mm) in 79.4% (HHUS) and 80% (ABVS). The correlation of size measurement was slightly higher for ABVS-MRI ($r = 0.89$) than for HHUS-MRI ($r = 0.82$) with $P < .001$.

Conclusions: ABVS can be used as an alternative to HHUS. ABVS has the advantage of operator independence and better reproducibility although it is limited in evaluating axillary lymph nodes and lacks Doppler or elastrography capabilities, which sometimes provide important supplementary information in HHUS.

Key Words: Breast lesions; ultrasonography; automated breast volume scanner (ABVS); BI-RADS.

INTRODUCTION

Magnetic resonance imaging of the breast (breast MRI) is typically performed in women at higher risk for breast cancer (eg BRCA-1 or BRCA-2 mutation). In Germany, most of these women are enrolled in special breast cancer screening programs, which include a breast MRI examination once a year (1). Other indications for breast MRI are inconclusive findings of mammography and handheld ultrasonography (HHUS) or the need to evaluate preoperative tumor extent, for example, in case of multifocality. Although breast MRI is highly sensitive, it has variable specificity and a high false-positive rate (2). Therefore, two-dimensional HHUS is also used as a second-look imaging test to reduce the false-positive rate, by easily identifying lymph nodes or fibroadenomas, classified as nonspecific enhancing lesions by MRI (1). The other advantage of second-look ultrasound is that it can help in deciding about the biopsy guidance method (ultrasound or MRI). Ultrasound-guided biopsy is preferred to MRI-guided biopsy and can be performed whenever the suspicious breast lesion is detectable by ultrasound (3). However, because HHUS is very operator-dependent, nonreproducible, and inefficient in the diagnosis of some breast malignancies (especially ductal carcinoma in situ [DCIS]) (4), the present study was conducted to investigate whether an automated breast volume scanner (ABVS) could overcome these limitations of HHUS.

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The ABVS acquires a whole series of consecutive B-mode images by scanning the whole breast in a straight line in anterior-posterior, lateral, and medial directions (and if necessary, eg in women with large breasts, additionally in superior and inferior directions). The acquired images are sent to a separate workstation and are then used to reconstruct three-dimensional (3D) datasets of the entire breast volume including coronal, axial, and sagittal views. The resulting datasets can then be analyzed by a radiologist. Thus, ABVS provides consistent, reproducible, and operator-independent ultrasound imaging of the entire breast (5). The examination takes 10 minutes (5) and can be performed by a technologist. Interpretation by a radiologist at the workstation takes another 5 minutes (6).

MATERIALS AND METHODS

Between August 2011 and October 2015, 28 women (mean age 44.6 years; range 26–76 years) with 39 examined breasts and at least one lesion demonstrated by breast MRI were included in the study. Half of the patients were high-risk patients, the other half were non–high-risk patients. In addition to MRI, each patient underwent HHUS and ABVS. In 21 cases, biopsy or surgical specimens were examined histopathologically. All malignancies were proven by histopathology.

Breast MRI was performed on a 1.5 T whole-body MR imager (Magnetom Avanto, Siemens Healthcare, Erlangen, Germany) using our standard breast protocol consisting of a precontrast paracoronal T1-weighted spin-eco sequence through the axilla, a precontrast axial T2-weighted fast spin-echo sequence without fat saturation, and an axial dynamic 3D gradient-echo sequence without fat saturation with acquisition of one precontrast and five series after administration of a weight-adapted dose of a gadolinium-based contrast medium material (each series with an acquisition time of approximately 1 minute) and one late postcontrast T1-weighted spin-echo sequence with fat saturation. The protocol is in accordance with the guidelines of the Breast Imaging Working Group of the German Radiological Society (7,8).

The manual ultrasound examination (HHUS) was performed either with the Toshiba Xario or with the Toshiba Aplio 80, each equipped with a 14L5 (5–14 MHz) linear transducer. All ultrasound examinations were performed as part of clinical routine. Patients were positioned in the supine position with both arms elevated above the head.

The ABVS examinations were performed using the ACUSON S2000 ABVS Ultrasound System with an integrated Siemens 14L5BV linear transducer (14 MHz; Siemens Medical Solutions). The technologist was instructed in handling the equipment and trained in performing ABVS before examining study patients. Patient positioning for ABVS was similar to that with HHUS. Each breast was scanned in anterior-posterior, medial, and lateral orientations and, if required, additionally in superior and inferior orientations. After acquisition, the axial image series were sent to the ABVS workstation for review. The workstation processes the dataset in various multiplanar reconstructions. For this study, transverse, sagittal, and coronal views were available. Figure 1 shows an example of the three multiplanar compounded ABVS reconstructions compared to HHUS and MRI.

MRI was evaluated and HHUS was performed by or under direct supervision of a fully trained radiologist specialized in breast imaging. Reports and digitally saved images as well as the ABVS datasets were retrospectively analyzed by a resident with 3 years of experience in breast imaging. The resident's experience in breast imaging is comparable to the experience of a fully trained radiologist. The resident was trained in ABVS image interpretation by Siemens Medical before study initiation. The number of lesions detected by MRI (minimum lesion size 5 mm), HHUS, and ABVS (for both, no size minimum) was counted. In addition, the reader was asked to define a "most suspicious" lesion or (if there was no suspicious lesion) the largest lesion, to measure lesion size, assign the lesion to a quadrant, and classify the lesion according to the American College of Radiology Breast Imaging Reporting and Data System (BI-RADS) for ultrasonography and MRI (0, incomplete; 1, negative; 2, benign finding(s); 3, probably benign; 4a, low suspicion of malignancy; 4b, intermediate suspicion of malignancy; 4c, moderate concern, but not classic for malignancy; and 5, highly suggestive of malignancy) (9). BI-RADS categories 2 and 3 were rated as benign and BI-RADS categories 4 and 5 were rated as malignant. No lesions were categorized at BI-RADS 0 or 1. MRI or, when available, histopathologic results of biopsy or surgical specimens served as gold standard in terms of lesion characterization and lesion size measurement (only MRI).

Sensitivity, specificity, diagnostic accuracy, and positive or negative predictive value were calculated for HHUS and ABVS. Accordance of HHUS and ABVS with the gold standard (MRI or, if available, histopathology) was calculated by Cohen kappa. Rate of malignancy according to the BI-RADS classification was analyzed for HHUS, ABVS, and MRI. In addition, agreement in the localization of the most suspicious/largest lesion between HHUS and MRI as well as between ABVS and MRI was analyzed. Correlation coefficients were analyzed based on scatter plots and Pearson correlation comparing lesion size measured in MRI to the size measured by both HHUS and ABVS. In addition, the number of accurately measured, under-, and overestimated lesion sizes compared to MRI was counted for HHUS and ABVS, considering size estimates of +/− 3 mm as accurate.

The responsible ethics committee did not require additional approval for this study design. However, written informed consent was obtained from all patients included.

RESULTS

A total of 39 breasts of 28 patients were examined by MRI, conventional ultrasonography, and ABVS. MRI detected 72 lesions, ABVS 59 lesions, and HHUS 54 lesions.