ELSEVIER

European Journal of Radiology 71 (2009) 109–115

EJR
EUROPEAN JOURNAL OF RADIOLOGY

www.elsevier.com/locate/ejrad

Analysis of 107 breast lesions with automated 3D ultrasound and comparison with mammography and manual ultrasound

D. Kotsianos-Hermle [a,*], K.M. Hiltawsky [b], S. Wirth [a], T. Fischer [a], K. Friese [c], M. Reiser [a]

[a] *Department of Clinical Radiology, University of Munich, Germany*
[b] *General Electric, Global Research, Garching, Germany*
[c] *Department of Gynaecology, University of Munich, Germany*

Received 7 March 2008; received in revised form 1 April 2008; accepted 2 April 2008

Abstract

Objectives: Our aim was to investigate the diagnostic potential of an automated ultrasound (US) breast scanner prototype and compare it with manual US and mammography.
Methods: Ninety-seven patients with a total of 107 breast lesions had mammograms, manual US and an automated breast US scan. Multiplanar reconstructions in coronal, axial and the sagittal view were reconstructed from the automated dataset and visualized. After biopsy, all lesions were confirmed histologically. The data were evaluated according to the BIRADS (Breast Imaging Reporting and Data System) classification. The sensitivity and specificity were analyzed.
Results: The BIRADS criterion "margin" was significantly related to the overall BIRADS classification, independently of the US method being used. The sensitivity of mammography was significantly lower than of each US method (Fisher's exact test with $p < 0.05$). There were no significant differences between the US methods.
Conclusions: The reconstructed third (axial) image plane of the whole breast, which corresponds to a craniocaudal mammogram, can give additional information about both, site and differential diagnosis of a lesion. Although image quality was sufficient, automated US is not good enough to replace manual US at this time.

Keywords: 3D ultrasound; Breast lesions; BIRADS; Mammography; Multiplanar reconstructions

1. Introduction

In manual ultrasound (US) a breast lesion has to be immediately characterized during the examination. A weakness of this method is the compromised possibility of a second evaluation on hard copies due to the lack of standardization of sonographic documentation. A solution is a dedicated breast imaging system for three-dimensional (3D) US breast imaging with the breast compressed in a manner similar to that in the X-ray mammography setup. We developed a prototype of an automated ultrasound breast scanner for this study, which allowed us to acquire an US volume dataset of the whole breast in a standard manner. From this dataset multiplanar reconstructions in three planes can be visualized. It is unique that the reconstructed images from the plane perpendicular to the US beam correspond to the craniocaudal image plane of the mammogram. We studied 97 patients, some with multiple breast lesions, with manual and automated US, and mammography. The study included data from 107 lesions, which had been confirmed histopathologically. Feasibility and image quality of the automated US breast scanner were good [1]. The study compared the diagnostic accuracy of the new method with these of manual US and mammography.

2. Materials and methods

We studied prospective 97 patients who had a clinical reason to have a mammogram—either breast pain, findings on palpa-

* Corresponding author at: University of Munich, Department of Clinical Radiology, Maistr. 11, 80337 Munich, Germany. Tel.: +49 89 5160 4111; fax: +49 89 5160 9202.
E-mail address: dorothea.hermle@med.uni-muenchen.de (D. Kotsianos-Hermle).

0720-048X/$ – see front matter © 2008 Elsevier Ireland Ltd. All rights reserved.
doi:10.1016/j.ejrad.2008.04.001

tion or found sonographically suspect lesions. For inclusion in the study lesions had to be morphologically classified as solid tumors or complicated cyst and have a margin of normal tissue. One hundred seven lesions were confirmed histopathologically. The benign solid lesions were biopsied, e.g. because of mammographic or clinical findings suggestive of cancer or on demand by patients. Cystic lesions were biopsied cause of breast pain or solid intracystic proliferation or hypoechogenicity. The study was approved by the Institutional Review Board for Human Investigation at the university. All patients gave their informed consent before the study.

2.1. Mammography and manual ultrasound

Mammograms were taken with a Senograph 2000 (GE Healthcare, Waukesha, WI) in craniocaudal (27 kV, 85 mAs, Mo/Mo) and mediolateral-oblique views (27 kV, 58 mAs, Mo/Mo). After mammography, a manual US examination was done by two radiologists using a LOGIQ 9 with a high-frequency matrix probe, the M12L linear transducer with multiple focal zones (GE Healthcare, Waukesha, WI). The breast was examined in overlapping antiradial scans (perpendicular to the ducts) and duct parallel (mamillo-radial). Modern algorithms (e.g. speckle reduction imaging) were used to optimize the image quality. With the patient supine, suspect regions were imaged in two perpendicular scanning planes (sagittal and axial) and DICOM images were stored on hard disks. The images of the mammogram and manual US were sent to an offline of a workstation (GE Logiq Works) for review and analysis. After the manual US examination, an automated US breast scan was done according to the following procedure.

2.2. Automated ultrasound

An automated US breast scanner was designed for the study, which consisted a Senograph 600 T (without its X-ray tube), a conventional LOGIQ 9 US system (GE Healthcare, Waukesha, Wisconsin) and a two-axis positioning table, which held a special sonolucent compression paddle and a standard linear US transducer (M12L probe). All examinations were made in craniocaudal view with an applied compression of 60 N. The US probe was moved back-and-forth over the compression paddle with a maximum number of four sweeps. Water was used between the transducer surface and the compression paddle, and coupling gel between the compression paddle and the breast (Fig. 1).

The sweeping scanning of the compressed breast and simultaneous acquisition of data were controlled by the US system. The scanner was able to cover a breast volume of 16 cm (in 2.5 min) in a mediolateral direction, 13.6 cm in an anterioposterior direction (4 sweeps of 3.4 cm each) and 6 cm in a craniocaudal direction, where the latter corresponds to image depth. To preserve the highest possible quality of image for later reconstruction, 0.4 mm was chosen as the scan spacing in the mediolateral direction. This resulted in 400 images (focal zones 7, frame rate 11 Hz, center frame 12 MHz) in each sweep and a maximum number of 1600 images/breast scan. We used the linear probe in virtual convex mode to cover the tissue close to the chest wall as well as possible. A three-dimensional DICOM dataset of the whole breast was obtained during the automated breast scan. From these data, multiplanar compounded reconstructions in coronal, axial and the sagittal views of the whole breast were generated in a standard manner. The reconstructed images from a plane perpendicular to the US beam correspond to the craniocaudal image plane of mammography. The examiner could choose a specific region of interest in any of the image planes mentioned above (say sagittal) and would automatically receive the corresponding regions in the other two image planes (axial and coronal).

Fig. 2 shows an example of the three multiplanar compounded reconstructions from the automated 3D US in comparison with the mammogram.

Fig. 1. Prototype of an automated US breast scanner for 3D imaging. There is a Senograph 600 T with a two-axis positioning table and a compression plate on the left and a Logiq 9 US system. On the right the linear M12L probe is mounted on the two-axis positioning table and being used to scan (GE Healthcare, Waukesha, WI).