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ORIGINAL ARTICLE

Real-time ultrasound elastography: Does it improve B-mode ultrasound characterization of solid breast lesions?

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KEYWORDS

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Abstract *Introduction:* Elastography is a non-invasive medical imaging technique that detects tumors based on their stiffness (elasticity). Strain images display the relative stiffness of lesions compared with the stiffness of surrounding tissue as cancerous tumors tend to be many times stiffer than the normal tissue, which "gives" under compression. An image in which different degrees of stiffness show as different shades of light and dark is called an elastogram.
Purpose: To prospectively evaluate the sensitivity and specificity of the real-time sonoelastography as compared with B-mode US for distinguishing between benign and malignant solid breast masses. The density of the glandular breast tissue was taken in consideration in addition to the Breast Imaging Reporting and Data System (BI-RADS) categories of the lesions, with biopsy results as the reference standard.
Methods: A total of 216 candidate solid lesions (123 benign and 93 malignant) in 188 patients were examined with 2-dimensional ultrasonography, elastosonography and mammography (for 147 patients). The lesions were classified according to the density of the glandular breast tissue into low density group (D1) and a high density group (D2) and were categorized with the BIRADS score. Elastographic images were assigned an elasticity score of 1 to 5 (1–3, benign; 4 and 5, malignant) according to the Multi-Center Team of Study and the strain ratios of the lesions were measured. Concordance between the imaging findings and histopathologic results was documented.

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Statistical analysis was performed and sensitivity, specificity and positive and negative predictive values for both elastography and conventional sonography were calculated.

Results: Elastography showed less sensitivity but higher specificity than conventional sonography in the differentiation of benign from malignant solid lesions: B-mode sonography had sensitivity of 85.1%, specificity of 93.9%, a positive predictive value of 92.5% and a negative predictive value of 87.8%, compared with the sensitivity of 80.1%, specificity of 97.1%, a positive predictive value of 96.8% and a negative predictive value of 82.1% for elastography. Elastography was superior to B-mode US in diagnosing solid lesions in the low density group (D1) (96.6% vs. 92.4% specificity) and less in the dense glandular tissue (97.8% vs. 95.9% specificity).

Conclusions: Real-time sonoelastography is an useful technique for the characterization of benign and malignant solid lesions as it increases the diagnostic specificity comparable to B-mode ultrasound, particularly in both ACR 1 and 2, thus reducing the false-positive rate.

1. Introduction

Breast ultrasonography (US) has become an invaluable tool for the detection of breast lesions: a decade ago, physicians found that the imaging features on ultrasonographic images could be used to classify benign and malignant solid breast masses and thus decrease the numbers of biopsies performed (1). US, however, is still strongly operator-dependant, and a correct diagnosis may be sometimes difficult because of the overlapping between the features of malignant and benign breast lesions, although they have been described (2–4) and categorized (5). Conventional ultrasound can distinguish benign from malignant breast lesions based on the appearance of the lesion: margin irregularity, shape, echogenicity and shadowing (2) (Table 1).

Compressibility has also been used to assess a lesion (6). Soft benign lesions will flatten more upon compression than hard malignant ones. However, this may be subjective and operator-dependent. Consequently, the diagnostic confirmation may often require image-guided biopsy procedures.

Recently, sonoelastography (SE), looking at the mechanical properties of tissues (relative stiffness) as opposed to conventional ultrasound, which looks at the backscatter of transmitted ultrasound waves through tissues (7). Elastography is the technique of imaging the hardness of soft tissue. Strain images display the relative stiffness of lesions compared with the stiffness of surrounding tissue. Stiffer areas deform less easily than do their surroundings and are depicted as dark on strain images, whereas softer areas deform more easily than do their surroundings and are depicted as light. Malignant masses typically appear dark and have high contrast with background breast tissue during deformation. Benign masses typically appear lighter and have lower contrast with background breast tissue during deformation (8). The interpretation criteria in elastography consist of the qualitative parameter elasticity score (ES) and the quantitative parameter strain ratio (SR). Various qualitative classifications that differentiate between 3 and 5 patterns have been reported for real-time elastography (RTE); the most frequently used one being that differentiates five RTE patterns, where patterns 4 and 5 indicate malignant breast lesions and patterns 1–3 indicate benign breast lesions (9). A semiquantitative method of lesion assessment, referred to as strain ratio measurement, has also been developed. Calculation of the SR value is based on determining the average strain measured in a lesion and comparing it to the average strain of a similar area of fatty tissue in the adjacent breast tissue. The SR reflects the relative stiffness of the lesion. Probability of malignancy increases as the SR value increases (10).

Table 1 Stavros criteria of benign versus malignant breast masses (2).

Criteria associated with benign lesion	Criteria associated with malignant lesion
Smooth shape (rounded, oval)	Irregular shape
Linear well defined margin	Ill defined/spiculated
Homogenous echotexture	Heterogenous echotexture
Iso, hypoechoic	Distorted architexture
Distal/edge shadowing	Central shadowing
Width to AP diameter ⩾1.4	Width to AP diameter ⩽1.4
Gentle lobulation	Micro-lobulation
Dilated ducts	Microcalcification

Tissue elasticity imaging is performed with a conventional ultrasound probe and does not require additional equipment. The calculation of tissue elasticity is in real-time and the resultant strain image is represented in color over the conventional B mode ultrasound. In addition, the B mode image can be displayed at the same time as the elastography strain image. This method combines the added information from elastography with the flexible manipulation of a free-hand probe (11).

The aim of the study was to prospectively evaluate the sensitivity and specificity of the real-time sonoelastography as compared with B-mode US for distinguishing between benign and malignant solid breast masses, taking into consideration the density of the glandular breast tissue and the Breast Imaging Reporting and Data System (BI-RADS) categories of the lesions (5), with biopsy results as the reference standard.

2. Materials and methods

Two hundred forty-three patients who underwent imaging of 292 solid focal lesions were enrolled between December 2009 and June 2010. Only pathologically proved lesions, 216 in 188 patients, were included in the study. Their ages were ranging between 18 and 72 years (mean age of 45 years). One hundred thirty-eight lesions were palpable (63.9%) and the remaining 78 lesions (36.1%) were nonpalpable. The inclusion criterion was demonstration of a solid focal lesion by ultrasound. This number represents the set of eligible cases,