Study of quantitative elastography with supersonic shear imaging in the diagnosis of breast tumours

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Abstract

Purpose. This study was undertaken to evaluate the value of quantitative elastography in the diagnosis of breast tumours.

Materials and methods. Conventional ultrasound (US) and quantitative elastography were performed in 108 women with 114 breast lesions by two experienced radiologists, and pathological results were available in all cases. For each lesion, the maximum, mean, and minimum (min) elasticity and elasticity ratio between lesions and surrounding tissue were measured. The Breast Imaging Reporting and Data System (BI-RADS) categories were assessed with conventional US in all lesions.

Results. Malignant lesions exhibited significantly higher maximum and mean elasticity (111.57±69.29 kPa and 54.49±33.70 kPa) than did benign lesions (59.00±45.35 kPa and 36.64±26.18 kPa) (p<0.01). For maximum elasticity versus BI-RADS, performance results were sensitivity 60.9 % vs. 78.3%, specificity 85.3% vs. 98.5%, positive predictive value (PPV) 73.7% vs. 97.3 %, negative predictive value (NPV) 76.3% vs. 87.0 % and accuracy 75.4% vs. 90.3%. BI-RADS had significantly better accuracy than maximum elasticity (p<0.01). Maximum and mean elasticity of invasive ductal carcinoma (IDC) were significantly higher than those of fibroadenoma (p<0.01), whereas the difference was not statistically significant with fibroadenosis, papilloma and inflammation (p>0.01). Maximum and mean elasticity and elasticity ratio of BI-RADS 5 were all significantly higher than those of BI-RADS 3 (p<0.01). Reliability for maximum and mean elasticity were almost perfect [intraclass correlation coefficients (ICC)=0.87 and 0.79].

Riassunto

Obiettivo. Valutare l’utilità dell’elastografia quantitativa nella diagnosi del tumore alla mammella.

Materiali e metodi. 108 donne con lesioni alla mammella sono state sottoposte ad ecografia convenzionale ed a studio elastografico quantitativo mediante supersonic shear imaging da due radiologi esperti; in ogni caso era disponibile il riscontro anatomopatologico delle lesioni. Per ogni lesione sono state misurate l’elasticità, media e minima, ed il rapporto di elasticità tra le lesioni e il tessuto circostante. In tutti i casi sono state stimate le categorie BI-RADS (the Breast Imaging Reporting and Data System) mediante ecografia convenzionale.

Risultati. Le lesioni maligne manifestavano elasticità massima e media significativamente maggiore (111,57±69,29 kPa e 54,49 ± 33,70 kPa) rispetto alle lesioni benigne (59,00±45,35 kPa e 36,64±26,18 kPa) (p<0.01). L’elasticità massima, nei confronti delle categorie BI-RADS, presentava sensibilità del 60,9 % vs. 78,3%, specificità del 85,3% vs. 98,5%, valore predittivo positivo (VPP) del 73,7% vs. 97,3 %, valore predittivo negativo (VPN) del 76,3% vs. 87,0 % ed accuratezza del 75,4% vs. 90,3%. Le categorie BI-RADS presentano un’accuratezza significativamente migliore dell’elasticità massima (p<0.01). L’elasticità media e massima del carcinoma duttale invasivo (CDI) è risultata significativamente maggiore rispetto al fibroadenoma (p<0.01), mentre non sono emerse differenze statisticamente significative con la fibroadenosi, il papilloma e l’inflammazione (p>0.01). Le lesioni con BI-RADS 5 presentavano tutte un’elasticità media e massima significativamente maggiore rispetto alle lesioni con BI-RADS 3 (p<0.01). L’affidabilità
Conclusions. Shear-wave elastography gives quantitative elasticity information that could potentially help in breast-lesion characterisation, although it cannot replace conventional BI-RADS in the differentiation of breast lesions.

Keywords Breast neoplasms · Ultrasonography · Shear-wave elastography · Diagnosis · Quantitative analysis

Introduction

Elastography is an emerging imaging technique that quantifies the “stiffness” of a breast lesion in relation to the background adipose and fibroglandular tissues [1, 2]. This property can be described by Young’s modulus which is defined as $E=\sigma/\varepsilon$ where $\sigma$ is the applied stress and $\varepsilon$ is the resultant deformation of the tissue.

In the last few years, sonoelastography has been applied to the diagnosis of breast, thyroid, muscle, liver, prostate disease [3–8]. It has been proved to be especially helpful in the differential diagnosis of breast lesions [9, 10]. Most previous studies used elastography scoring (ES) or strain ratio measurement (SR) as the diagnostic parameter, both of which are semi-quantitative parameters. Todd et al. reported a sensitivity of 0.76 for ES and 0.79 for SR, and a specificity of 0.81 for ES and 0.76 for SR [11].

Shear-wave elastography (SWE) is a new method for obtaining elastography images. With this method, the radiation force is produced by the probe rather than the operator [as applied in conventional ultrasound (US) elastography]. Transient pulses are used to generate propagating shear waves in the body, and elasticity is directly calculated by measuring the wave propagation speed. Within a given region of interest (ROI), defined by an electronic cursor, values for stiffness maximum, mean and standard deviation (SD) are produced. Thus, areas of stiffness can be quantitatively described.

Until recently, the published literature on SWE of the breast was limited to just a few studies. One study, comprising only 15 patients, demonstrated good differentiation between fatty tissue, dense parenchyma and benign and malignant lesions by mean elasticity [12]. Another paper demonstrated that shear-wave elastography was helpful in differentiating benign from malignant breast masses and may increase the ability of breast US to differentiate between benign and malignant masses [13]. Evans et al. [14] demonstrated that SWE could provide quantitative and reproducible information on solid breast lesions with diagnostic accuracy at least as good as conventional US with Breast Imaging Reporting and Data System (BI-RADS) classification. However, these studies have only limited elasticity parameters and did not assess the correlation of elasticity and BI-RADS.

The study reported here evaluated the role and accuracy of SWE in characterising breast nodules and differentiating between malignant and benign lesions by using multiple elasticity values. We also assessed the correlation of elasticity with conventional US BI-RADS.

Patients and methods

Patients

From March 2010 to June 2010, a prospective study was conducted at our institute to evaluate the utility and diagnostic performance of quantitative elastography using the Aixplorer US system (SuperSonic Imagine, Aix en Provence, France). The study population consisted of consecutive patients referred to our centre for US-guided biopsy of a sonographically apparent breast lesion. Patients were included following their consent. We excluded pregnant and lactating women, those with breast implants, women receiving chemotherapy or radiotherapy for any cancer, those with biopsyed skin masses and those with a history of ipsilateral breast surgery. Pathological diagnosis was used as the reference standard.

We assessed 108 consecutive patients with 114 solid lesions, of whom 65 were asymptomatic, 41 presented with a palpable mass and two reported nipple discharge. Their ages ranged from 18-65 (mean±SD, 42.8±8.69) years. Of these patients, 102 had a single nodule and six had two nodules. The maximum nodule diameter ranged from 5.1 to 38 mm (mean±SD 14.61±14.30 mm). Informed consent was obtained from all patients, and the study was approved by our local ethics committee. Written informed consent was obtained from every patient at enrolment.