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Endoscopic Ultrasound Elastography

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Key Words
Elastography · Endoscopic ultrasound · Pancreatic masses · Ratio elastography

Abstract
Sonoelastography is based on the knowledge that some diseases, such as cancer, lead to a change in tissue hardness. Elastography examines the elastic properties of tissues by applying a slight compression to the tissue and comparing the images obtained before and after this compression. Endoscopic ultrasonography (EUS) is today the best technique to diagnose a small pancreatic mass and to determine the histology of such lesions. However, the accuracy of EUS-FNA is around 85–90%. In this study, elastography was used to differentiate benign from malignant pancreatic masses. The bright future of the second generation of elastography, the quantitative elastography or ratio elastography, is also discussed.

Introduction

The introduction of endoscopic ultrasonography (EUS) represented a major advance in the diagnosis and staging of gastrointestinal malignancies. In addition to imaging of tumors and improving TMN staging, EUS also provides guidance for fine needle aspiration (FNA) and biopsy sampling of undiagnosed masses and lymph nodes (LN) suspicious for malignant invasion, providing further diagnostic and staging information. However, FNA is technically demanding, and multiple punctures of LN or masses are sometimes required to obtain sufficient tissue for histological assessment. The fact that pancreatic masses have a wide differential diagnosis that includes benign and malignant etiologies and FNA of the pancreas is associated with a small, but non-insignificant, risk of pancreatitis deserves further consideration [1]. Hence, the ability to more accurately evaluate masses and LN prior to sampling in an effort to aid in targeting lesions for FNA and possibly reduce complications would be welcomed by echo-endoscopists. At least two strategies have been developed with these goals in mind: contrast-enhanced endosonography and sonoelastography.

Theory and Technical Aspects of Sonoelastography

Sonoelastography is based on the knowledge that some diseases, such as cancer, lead to a change in tissue hardness (i.e. the so-called elasticity modulus) and is an outgrowth of the well-known breast ultrasound fremitus technique [2–4], during which the patient is asked to

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hum while color or power Doppler is used to examine the breast. Softer portions of the breast vibrate more in response to the humming, while cancers and other firm masses vibrate less and thus are seen as areas of decreased color, even if they are isoechoic on the ordinary B scan. Elastography examines the elastic properties of tissues by applying a slight compression to the tissue and comparing the images obtained before and after this compression. The data before and after imaging are then compared, using a cross-correlation technique to determine the amount of displacement each small portion of tissue undergoes in response to the compression applied by the ultrasound transducer [5–7]. The elasticity modulus, i.e. the tissue elasticity distribution, can be calculated from the strain and the stress of the structures examined. While the strain field can be estimated from the radiofrequency signals returned from tissue structures before and after compression, it is impossible to measure the stress field directly within the tissue. Another problem is that the compression of harder tissue structures is often followed by a lateral displacement of these structures [8]. It is nearly impossible to represent the volume of this sideslip with conventional 2D methods, but its calculation is indispensable for an accurate determination of the tissue elasticity of the structures examined. To overcome these problems, the extended combined autocorrelation method has been developed, which allows the reconstruction of tissue elasticity of the structures examined on the basis of the 3D finite element model. The new technique enables highly accurate estimation of the tissue elasticity distribution and adequate compensation of sideslips. Imaging of elasticity can be performed in real time with the sonoelastography module that can be integrated into the platform of the Hitachi EUB-8500 system (Hitachi Medical Systems Europe, Zug, Switzerland).

Procedure Technique and Criteria

Similar to traditional color Doppler imaging, EUS tissue elasticity imaging is performed with conventional EUS probes and does not require additional instruments (e.g. for measuring pressure or producing vibrations). The vibrations and compressions are provided physiologically by vascular pulsation and respiratory motion. The calculation of the tissue elasticity distribution is performed in real time and the examination results are represented in color superimposed on the conventional B-mode image.

To date, the majority of clinical research involving sonoelastography has been focused on the evaluation of breast masses. Three different patterns have been identified in elastograms of breast cancers: a well-defined, very hard (dark) mass or nodule; a moderately hard mass or nodule containing much harder (darker) foci inside, and a very dark or hard central core surrounded by a somewhat softer or less dark peripheral component [4]. Although with conventional ultrasound or EUS fibrosis generally appears as a hyperechogenic region with posterior acoustic shadowing (an appearance also seen in cancers), in elastography it generally appears as a uniform, moderately hard region with no distinct foci of increased hardness. Preliminary work in breast tissue elastography has shown that it can correctly classify most benign and malignant masses [4].

Second Generation of Elastography: Ratio Elastography

Strain ratio was developed to add quantitative diagnostic information to pattern recognition. Strain ratio is expressed as the ratio of lesion hardness to connective tissue or fat tissue hardness. Strain ratio is based on the assumption that the hardness of connective tissue or fat tissue does not vary between individuals. What we must keep in mind is that colors represented in this system are relative to each region of interest (ROI). In this context, the relationship between the color patterns of lesions and those of surrounding tissue sometimes provides the most meaningful data. EUS elastography provides additional important information relating to hardness, i.e. its distributed pattern. Regardless of ROIs, the distributed pattern is theoretically a constant. The prototype image analysis software used here extracts various features from real-time tissue elastography images. It converts the red-green-blue values inside the ROI of the elastography image into a relative strain value and calculates other features of the elastography image, such as the mean of the relative strain value, the standard deviation of the relative strain value, and the proportion of the blue (low strain) region in the region analyzed, and determines the complexity of the blue (low strain) region in the region analyzed [(perimeter of the blue region)(area of the blue region)]. With this software (produced in cooperation with Hitachi), it is possible to demonstrate the uniformity (or lack thereof) of a target lesion and quantify the number of objective parameters of the distribution of hardness [9].