Elastography of the Abdomen

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KEYWORDS

• Elastography • Liver fibrosis • Cirrhosis • Liver • Strain • Stiffness • Ultrasound • Pancreas

KEY POINTS

- There are 2 types of elastography, strain elastography that is qualitative and shear wave elastography that is quantitative.
- Although malignant focal liver lesions are statistically stiffer than benign lesions, there is a large overlap. Therefore, for any individual lesion, elastography is limited in characterizing the lesion as benign or malignant.
- Shear wave elastography is an excellent method for noninvasive evaluation of liver fibrosis.
- Elastography can characterize fluid collections as serous or mucinous.
- Stiffness measurements of the liver and or spleen may be a noninvasive method of assessing hepatic venous pressure.

INTRODUCTION

Ultrasound elastography is a new technique that generates images based on the stiffness of tissue as opposed to anatomy. Many disease states have changes in stiffness that can be detected by elastography. Ultrasound elastography has been used to evaluate multiple organs.[1,2] There are 2 elastography techniques presently available: strain elastography (SE) and shear wave (SWE) imaging.[3,4]

Focal liver masses have a mixed appearance on elastography, with a large overlap in the stiffness of benign and malignant lesion making characterization of focal liver masses problematic with elastography.[5] However, diffuse liver disease, such as fibrosis, can be graded and monitored with SWE. Shear waves do not propagate in simple fluid.[3] Initial studies suggest shear wave imaging may be helpful in characterization of a cystic lesion as serous or mucinous in nature.[1] Evaluation of other abdominal organs has been limited.

Diffuse liver disease is one of the major health problems in the world. Hepatitis is a group of liver disorders characterized by liver inflammation and necrosis of hepatocytes. Hepatitis can be acute or chronic if these changes persist for at least 6 months. Hepatitis C (HCV) and hepatitis B (HBV) viruses are the leading causes of chronic liver disease. It is estimated that 180 and 350 million people worldwide are infected with HCV and HBV, respectively. Annual mortality is estimated at 500,000 to 700,000 and 350,000 as a result of HBV-related and HCV-related liver diseases, respectively.[6–8]

In patients with HCV, failure to spontaneously eradicate infection occurs in 50% to 90% of cases depending on the route of transmission, presence

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of symptomatic hepatitis, and age at which infection occurred.[9] In Western countries, liver disease caused by HCV is the main indication for liver transplantation.

Chronic liver damage results in hepatic fibrosis characterized by an increase in extracellular matrix material produced by fibroblast-like cells in the hepatic parenchyma.[10] Consequently, the liver becomes stiffer than normal and the distortion of normal liver architecture can cause portal hypertension. Fibrosis is the feature mostly related to the progression of chronic hepatitis. It may progress toward liver cirrhosis, leading to hepatic failure, increased risk of hepatocellular carcinoma (HCC), and eventually, death.

The histologic evaluation of liver biopsies is carried out using scoring systems that produce values for various categories of inflammation (grade) and fibrosis (stage). There are several scoring systems all categorizing similar features. In the assessment of HCV chronic hepatitis, the most reproducible scoring system is the Metavir. On the Metavir scoring system, liver fibrosis is evaluated semiquantitatively and staged on a 5-point scale from 0 to 4 (F0, absent; F1, enlarged fibrotic portal tract; F2, periportal or initial portal-portal septa but intact architecture; F3, architectural distortion but no obvious cirrhosis; and F4, cirrhosis).[11]

Liver disease progression takes place over several decades and is accelerated by the presence of cofactors, such as alcohol consumption, diabetes mellitus, older age of acquisition, human immunodeficiency virus (HIV) coinfection, or coinfection with other viruses.[6] Depending on the presence of cofactors, between 10% and 40% of patients with chronic HCV infection will develop cirrhosis.[12] The prognosis of chronic liver disease is strongly dependent on the extent of liver fibrosis with life-threatening complications that may occur in patients with cirrhosis. Death related to the complications of cirrhosis occurs at an incidence rate of approximately 4% per year, whereas HCC occurs in this population at an estimated incidence rate of 1% to 5% per year.[13] Thus, a precise estimate of the degree of liver fibrosis is essential for surveillance, treatment decisions, and estimation of prognosis.[14–16]

Assessment of liver disease severity is recommended before therapy. As reported in 2012 EASL guidelines for the management of HCV infection,[6] treatment should be initiated promptly in patients with advanced fibrosis (Metavir score F3-F4) and strongly considered in patients with moderate fibrosis (Metavir score F2).

The cirrhotic transformation of the liver is associated with structural and biological changes responsible for an increase in portal pressure.[17] Although liver biopsy remains the standard for establishing the diagnosis of diffuse liver disease, it is an invasive method associated with patient discomfort and, in rare cases, serious complications,[18–20] and it is limited by significant intra-observer and interobserver variability and sampling errors.[21–23] A noninvasive method of determining liver fibrosis could lead to improved screening for early fibrosis allowing for treatment at a stage that has improved outcomes. Furthermore, this will allow for a noninvasive method to monitor the effect of treatments.

PRINCIPLES OF ELASTOGRAPHY

Elastography is a new technique in ultrasound, which can provide clinically useful information that was previously not available. Elasticity imaging or elastography is an imaging modality based on tissue stiffness rather than anatomy. Palpation has been used to evaluate for a malignancy for over a thousand years.[24] Ultrasound elastography can be considered as the imaging equivalent of palpation being able to quantify the stiffness of a lesion, which was previously judged only subjectively by physical examination.

There are 2 types of elastography: SE and SWE imaging.[3] SE produces an image based on how tissues respond to a displacement force from an external or patient source. This displacement force allows for a qualitative assessment of the lesion. SWE applies a special strong low-frequency acoustic radiation force impulse (ARFI) pulse (push pulse) that results in shear wave propagation that can be measured as a velocity. Because the shear wave speed through tissues depends on the stiffness of the tissue, a quantitative value of the stiffness can be obtained. A more detailed discussion of these techniques can be found elsewhere.[4]

SE

SE determines the relative strain or elasticity of tissue within a field-of-view (FOV).[3] The more an object deforms when a force is applied, the higher the strain and the softer the lesion. To determine the strain of a tissue or lesion, one must evaluate how the lesion deforms when an external force is applied. For example, if an almond was in a bowl of gelatin and the gelatin was pushed down on, the gelatin would deform, indicating it has high strain and is therefore soft. However, the almond would not deform, having low strain, and is therefore hard.

SE is performed on standard ultrasound equipment with specific software that evaluates the frame-to-frame differences in deformation in tissue when a force (stress) is applied. The force