By Drs A GUIBAL, A RODE, G RENOSI, J-Y SCOAZEC, M. VALIN, J DUMORTIER & T LEFORT

Evaluating liver fibrosis with a breakthrough ultrasound technology: Shear Wave Elastography

Liver fibrosis is a common consequence of all chronic liver diseases; cirrhosis can result from the evolution of liver fibrosis and is an important endpoint in patient management. Currently, liver biopsy is the standard diagnostic tool used to estimate the advancement of liver fibrosis. Unfortunately, this invasive method gives a limited sample of the liver and is associated with a non-negligible morbidity rate [1]. In order to repeatedly evaluate liver fibrosis during patient monitoring, non-invasive techniques such as elastography have been developed.

Fibrosis causes an increase in liver stiffness; elastography can thus be useful in the evaluation of the liver fibrosis. There are two main methods using ultrasound to estimate tissue stiffness. Firstly, strain-based approaches estimate differential displacements resulting from an applied deformation. However, such approaches do not provide a direct estimate of tissue stiffness and do not quantify tissue elasticity [2]. The second main method used in ultrasound elastography estimates shear wave velocities in tissue. Two methods — Acoustic Radiation Force Impulse or ARFI, and FibroScan — that use shear wave velocities have the advantage of providing a quantifiable, direct estimate of tissue elasticity, as the shear wave speed is directly proportional to the tissue elasticity or stiffness [3-6]. However, these techniques only provide a shear wave velocity estimate for a single region of interest and do not provide an elastography image of the tissue being analyzed.

A new technology known as ShearWave™ Elastography (SWE™) has been developed and incorporated into a complete ultrasound system. For the first time, an absolute quantification of tissue elasticity (measured in kilopascals) can now be obtained and displayed in a 2D color-coded image overlaid on top of a B-mode image for anatomical correlation and guidance [7]. The 2D SWE image combined with an anatomical reference enables visualization of spatial variations of liver stiffness and ensures location of stiffness measurements. The technology is non-invasive, independent of the skill level of the user, reproducible and carried out in real-time, making it a tool that is reliable and easy-to-use [7].

Aymeric Guibal, MD Guilaume Renosi, MD and **Thibaud Lefort**, MD are at the Hospices Civils de Lyon, Hôpital Edouard Herriot, Service d'Imagerie Digestive, 69437 Lyon cedex 03. France

Agnès Rode, MD is at the Hospices Civils de Lyon, Hôpital Croix Rousse, Service d'Imagerie Digestive, 69317 Lyon cedex 04. France

Jean-Yves Scoazec, MD is at the Hospices Civils de Lyon, Hôpital Edouard Herriot, Service d'anatomo-pathologie, 69437 Lyon cedex 03, France

Mélanie Valin, MD and **Jerome Dumortier**, MD are at the Hospices Civils de Lyon, Hôpital Edouard Herriot, Fédération des Spécialités Digestives, 69437 Lyon cedex 03, France Corresponding author Thibaud Lefort, Pavillon H, Hôpital Edouard Herriot, 69437 Lyon cedex 03, France Tel + 33 472 11 75 40 email lefort_thibaud@yahoo.fr

CASE STUDIES

The following cases illustrate the clinical benefits provided by ShearWave Elastography in the diagnosis of hepatologic conditions before a liver biopsy.

CASE 1

This was a 58 year old female with recently discovered chronic liver disease secondary to a Hepatitis B viral infection.The CT image of this patient presents a slight modification in liver morphology. The contours of the liver lobes are regular, but the edges are slightly rounded off [figure 1. a and b.]. The segments I and segments IV are of normal size and the parenchyma is homogeneous.

Conventional gray scale ultrasound was carried out the day after the CT scan. The ultrasound exam found moderate hepatic dysmorphy, with regular liver borders, but no signs of advanced liver cirrhosis or suspicious liver lesions.

Two weeks after the CT scan was taken a ShearWave Elastography exam and a biopsy were then carried out.

The biopsy was taken using 16 gauge needle (Biopsygun) and was immediately followed by a SWE exam in the same section (junction between segments V and VIII). Biopsy samples measuring 12mm in length were immediately put in 10% formol. After staining by Masson's trichrome, it could be seen that the hepatic tissue architecture was disrupted with extensive fibrosis and mutilation showing a cirrhogenic process.

The biopsy results were thus compatible with a cirrhogenic evolution (METAVIR F4) of chronic viral hepatitis, in

FIGURE 1. a and b. Case 1. Scanner image in portal phase shows the axial and coronal planes. The contours of the liver lobes are regular, but the edges are slightly rounded. Segments I and IV are of normal size and the parenchyma is homogeneous.

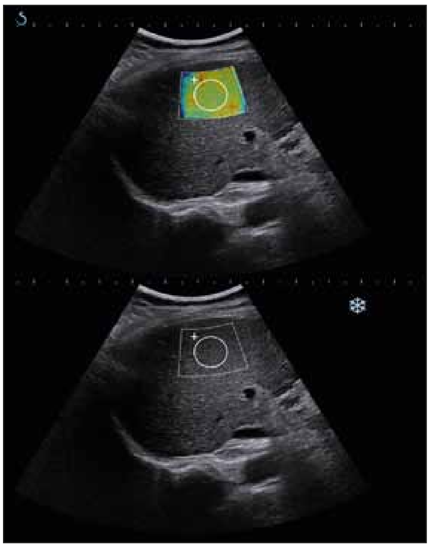

FIGURE 2. Case 1. ShearWave Elastography image carried out on the junction between the segments V and VIII intercostally. The quantitative measure ofelasticity showed stiffness values of 23 kPa, highly suggestive of an advanced cirrhosis. The standard deviation of the stiffness value in the region of interest was ± 1.1 kPa.

addition to the presence of slight steatosis with less than 30% hepatic cells.

ShearWave Elastography showed marked and inhomogeneous elevations in tissue stiffness of the hepatic parenchyma that had appeared only slightly morphologically abnormal on the conventional ultrasound exam [figure 2]. With the high kPa, elasticity results ShearWave Elastography suggested advanced fibrosis. This suspicion was confirmed by histology to be in fact cirrhosis of the liver.

CASE 2

This was a 62 year old male who had received a liver transplant six years ago following cirrhosis of the liver due to Hepatitis C infection.

A conventional ultrasound exam was carried out with the results showing the hepatic parenchyma to be normal and homogeneous but with a significant hepatic steatosis.

A ShearWave Elastography exam was carried out followed immediately by a biopsy in segment III of the liver.

The results of the ShearWave Elastography exam showed elevated levels of liver stiffness [figure 3]. The patient underwent a liver biopsy carried out on segment III; a good quality tissue sample measuring a total of 17mm in length was obtained.The biopsy results revealed the presence of lesions compatible with a reinfection by Viral Hepatitis C of the transplanted liver, confirming the ShearWave Elastography results. In addition, a massive steatosis was observed with a fibrosis METAVIR A1F2 score.

CONCLUSION

It can be seen from these two case studies that the tissue stiffness results provided by ShearWave Elastography correlate with the pathology results from biopsy.

ShearWave Elastography is a real-time, non-invasive, quantifiable method and could have a significant impact on fibrosis detection, diagnosis and disease follow-up. This could be helpful in validating the absence of fibrosis in order to reduce the number of unnecessary liver biopsies. In addition, the technique

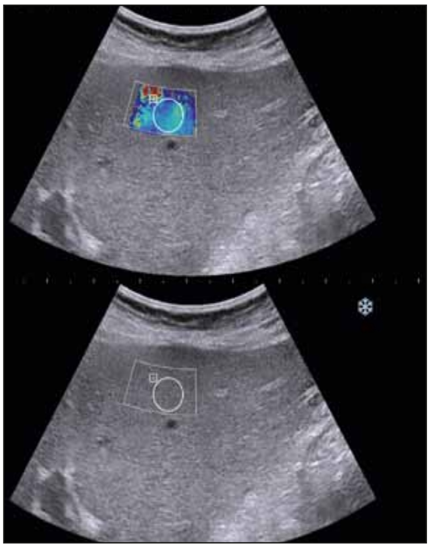

FIGURE 3. Case 2. ShearWave Elastography images showing stiffness values of 12.7 kPa (standard deviation ± 2.2 kPa.

could be also useful to confirm cirrhosis so avoiding dangerous biopsies and the possibility of hemorrhage. ShearWave Elastography could also guide the taking of biopsies, thus increasing tissue sample sensitivity.

More studies need to be undertaken with ShearWave Elastography to better understand and to confirm the promising results achieved thus far.

REFERENCES

1. Foucher J, Chanteloup E, Vergniol J et al. Diagnosis of cirrhosis by transient elastography (FibroScan): a prospective study. Gut 2006; 55: 403-408.
2. Tanter M, Bercoff J, Athanasiou A et al. Quantitative assessment of breast lesion viscoelasticity initial clinical results using supersonic shear imaging. Ultrasound in Med & Biol 2008; 34: 1373-1386
3. Muller M, Gennisson Jean-Luc, Deffieux T, Tanter M, Fink M. Quantitative viscoelasticity mapping of human liver using supersonic shear imaging; preliminary in vivo feasibility study. Ultrasound in Med & Biol 2009; 35: 219-229.
4. Bota S, Sporea I, Sirli R, Popescu A, Danila M, Sendroiu M. Factors that influence the correlation of Acoustic Radiation Force Impulse (ARFI), elastography with liver fibrosis. Med Ultrason 2011; 13: 135-140.
5. Rifai K, Cornberg J, Mederacke I, et al. Clinical feasibility of liver elastography by acoustic radiation force impulse imaging (ARFI). Dig Liver Dis 2011; 43: 491-497.
6. Toshima T, Shirabe K, Takeishi K, et al. New method for assessing liver fibrosis based on acoustic radiation force impulse: a special reference to the difference between right and left liver. J Gastroenterol 2011; 46: 705-711.
7. Bercoff J, Tanter M, Fink M. Supersonic shear imaging: a new technique for soft tissue elasticity mapping. IEEE Trans Ultrason Ferroelectr Freq Control 2004; 51: 396-409.