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REVIEW ARTICLE

Review of ultrasound elastography techniques in the liverRichard Assaker¹, MD, Orpheus Kolokythas², MD,
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Abstract

Liver fibrosis is a multifactorial chronic parenchymal disorder that can lead to cirrhosis with detrimental complications like portal hypertension and development of hepatocellular carcinoma. Until recently the gold standard for diagnosing liver cirrhosis and fibrosis has been liver biopsy. However associated complications are pain, bleeding, infection, and puncture of other organs. Another limitation is sampling error, that can lead to false negative results, and the potential need for sedative measures. Thus noninvasive imaging modalities have been investigated with the goal to replace invasive biopsy. Since hepatic fibrosis is associated with loss of elasticity (i.e. increased stiffness) of hepatic parenchyma, imaging and quantification methods for stiffness including magnetic resonance imaging elastography (FMRE) and ultrasound elastography (UE) have been developed, with the concept of measuring the degree of tissue stiffness as a surrogate marker for the stage of fibrosis. In this article we give an introduction to the various sonographic principles of ultrasound elastography, describe the advantages and limitations of the different techniques. We discuss how to set up and perform liver elastography in daily practice and how to apply the guidelines setup by various societies along with measures for quality assurance including training of sonographers and appropriate interpretation of images. Finally, the potential pitfalls and artifacts seen in liver UE are discussed as well.

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Introduction

Liver fibrosis is a multifactorial chronic parenchymal disorder that can lead to cirrhosis with detrimental complications like portal hypertension and development of hepatocellular carcinoma (1). Fibrosis marks a turning point in the clinical management of chronic liver disease with staging of fibrosis representing an important element for prognosis and treatment decisions. Until recently the gold standard for diagnosing liver cirrhosis and fibrosis has been liver biopsy. However associated complications are pain, bleeding, infection, and puncture of other organs (1). Another limitation is sampling error, that can lead to false negative results, and the potential need for sedative measures (2). Thus noninvasive imaging modalities have been investigated with the goal to replace invasive biopsy. Since hepatic fibrosis is associated with loss of elasticity (i.e. increased stiffness) of hepatic parenchyma, imaging and quantification methods for stiffness including magnetic resonance imaging elastography (FMRE) and ultrasound elastography (UE) have been developed, with the concept of measuring the degree of tissue stiffness as a surrogate marker for the stage of fibrosis.

UE was introduced as a tool for the evaluation of elastic properties of tissues in 1991 and with UE tissue stiffness can be determined qualitatively or quantitatively (3, 4). Numerous studies over the recent years have demonstrated reproducible results in the sonographic measurement of hepatic stiffness using various methods of UE (3, 4). The Society of Radiologists in Ultrasound (SRU) has endorsed UE as a reliable tool to accurately and non-invasively determine the presence and stages of fibrosis in the liver (5).

In this article we give an introduction to the various sonographic principles of ultrasound elastography, describe the advantages and limitations of the different techniques. We discuss how to set up and perform liver elastography in daily practice and how to apply the guidelines setup by various societies along with measures for quality assurance including training of sonographers and appropriate interpretation of images. Finally, the potential pitfalls and artifacts seen in liver UE are discussed as well.

Techniques of ultrasound elastography

USE can be broadly divided based on the type of elasticity moduli measured and method of data acquisition into two groups (6):

1. Shear Wave Imaging
 - a. 1D Transient Elastography (TE)
 - b. Point Shear Wave Elastography (pSWE, Acoustic radiation force quantification imaging (ARFI))
 - c. 2D Shear Wave Elastography (SWE)
2. Strain imaging
 - a. Strain Elastography (SE)
 - b. Acoustic Radiation Force Impulse (ARFI) strain imaging

Both strain and shear wave techniques rely on a stress force that is applied to the target organ, which will induce a strain on tissue. This applied pressure causes tissue displacement, which allows the determination of the elasticity of the tissue. The difference between both techniques lies in the type of mechanical excitation applied on the tissue and the measured parameters. Strain imaging uses physical me-

chanical force application on the tissues while SWE uses acoustic impulse to generate shear waves in the tissue allowing for the assessment of tissue stiffness (3).

I. Shear wave Elastography (SWE):

SWE is a dynamic method that can directly quantify tissue elasticity. The basic principal of SWE is the following: a portion of the longitudinal waves generated by acoustic impulse is converted to shear waves through the absorption of acoustic energy. The speed of the shear waves perpendicular to the plane of excitation is then measured and then either directly reported as meters per second (m/s) or converted by Young's modulus to kilopascals (kPa) in order to provide a quantitative estimate of tissue elasticity (6). Different methods of SWE can be used and there are currently three technical approaches for SWE:

- 1) One-dimensional transient elastography (TE),
- 2) Shear wave elastography
 - a. Point shear wave elastography (pSWE), and ARFI
 - b. Two-dimensional shear wave elastography (2D-SWE).

1. *Transient elastography (TE)*

Transient elastography was the first non-2D imaging elastography method developed and consists of two parts: a vibrator and a transducer. A mechanical vibrator produces low frequency (50-500hz) vibrations in the tissue. These waves then propagate in the target organ and their velocity is measured via a single channel transducer. The results are measured in kPa and range from 2.5 to 75. At least 10 measurements should be obtained with a ratio of at least 60% of valid shots to total

shots taken (7). To optimize the results and limiting sampling errors, transient elastography should be performed from several sites within the liver (8). Using this method, the commonly used value of >7 kPa defines significant fibrosis (F2 to F4) and has an estimated sensitivity of 70%, with a specificity of 84%. As for cirrhosis the cutoff value used is between 11 and 14 kPa with a sensitivity of 87% and a specificity of 91%. In a meta-analysis including 50 studies, the area under the receiver operator characteristic (AUROC) curve showed mean values of 0.84, 0.89 and 0.94 for the diagnosis of moderate fibrosis (F2), severe fibrosis (F3) and cirrhosis (F4) respectively.

For patients with chronic hepatitis C (HCV) the cutoff value for diagnosing cirrhosis is between 11 and 14 kPa, whereas in patients with hepatitis B (HBV), the cutoff value for diagnosing cirrhosis is between 9 and 10 kPa based on studies performed on Asian populations (9). This technique has its disadvantages, the most important of which is that it does not provide a 2D image, which is essential for accurate tissue targeting. Another limitation of TE is that it cannot accurately differentiate between the different stages of liver fibrosis (10). Due to the ease of using this instrument and technique, transient elastography is commonly used by non-radiology users mainly as a screening tool for fibrosis and cirrhosis.

2. Shear wave elastography: An alternative to the transient elastography method is shear wave measurement, which includes acoustic radiation force impulse (ARFI) quantification, point SWE and 2-D SWE.

a. Point SWE (pSWE)

Point shear wave elastography records the speed of the shear wave propagating through

the tissues. The same probe as the one used to image the liver is used to generate and monitor the propagation of the shear waves. The same approach is used in pSWE as in TE, however a conventional ultrasound image is available simultaneously to ensure accurate placement of the SWE box (Figure 1). Minimal

probe pressure and a short breath-hold in mid-respiratory position are preferred for better results (6). Multiple sites are recorded in the liver with the SWE box usually being small (10 mm x 5mm). The measurements are reported either in meter per seconds (m/s) or in kilopascal (kPa).

Figure 1. Point SWE - US image of the liver showing point Shearwave elastography (SWE). The box like structure is the area in which the measurements of the SWE are acquired. PSWE has the advantage of showing the ultrasound image in addition to providing the stiffness information in the liver.

According to Bamber *et al.* (11) and Jeong *et al.* (3) the advantage of pSWE compared to TE is that this method has been shown to be useful in diagnosing liver fibrosis with a higher success rate than TE, but with a similar predictive value for significant fibrosis and cirrhosis. The disadvantages of pSWE however are that this technique is operator dependent and only one measurement is taken at a time (3, 11).

Measurements are usually taken from the right lobe of the liver due to higher accuracy of measurements. The sensitivity for the diagnosis of significant fibrosis ($F \geq 2$) is 75 % and is 90% for diagnosing cirrhosis ($F4$) with specificities of 85 and 87 % respectively (12). As recommended by Friedrich-Rust *et al.* (13), the cutoff values in the diagnosis of liver fibrosis with pSWE are shown in table 1.

Table 1: Cut off values established for pSWE as per Friedrich-Rust *et al.* (13)

Fibrosis level	Cut off value (m/s)	Sensitivity (%)	Specificity (%)
>F2	1.34	79	90
>F3	1.55	86	86
>F4	1.8	92	86

In a meta-analysis of 13 studies including 1163 patients with chronic liver disease, pSWE was compared to TE with liver biopsy as the gold standard technique. pSWE had a lower rate of failure when compared with TE with a 2.1 % vs 6.6 % failure rate respectively. However both imaging techniques had similar sensitivities for diagnosing significant fibrosis ($F \geq 2$), 74% and 78% respectively, as well as for diagnosing cirrhosis, 87 and 89% respectively. The specificity for diagnosing significant fibrosis was 83% and 84% respectively, and 87% for cirrhosis in both imaging modalities (12).

b. ARFI

ARFI for quantification generates high intensity short duration pulse waves using multiple push beam pulses in the target tissue; the propagation of these waves is measured according to their velocity in m/s via conventional ultrasound or their conversion unit in kPa (14). The results and the assessment of liver fibrosis in ARFI elastography have been shown to be as accurate as TE. Friedrich-Rust *et.al* published a meta-analysis including 518 patients with chronic liver disease and showed Area under Receiver Operating Characteristic (AUROC) mean values of 0.87 and 0.91 for predicting significant fibrosis ($F \geq 2$) and severe fibrosis ($F \geq 3$) for cirrhosis with an Intraclass Correlation Coefficient (ICC) of 0.87(13).

c. 2-D SWE

In 2-D SWE focused ultrasound beams are used to generate shear waves at a frame rate up to 5000 frames/s. Using ARFI, multiple measurements are taken over a large field of view and from multiple sequential points.

This can be done as a single image or performed in real time (in B-mode view). The shear wave elastography map should avoid large vessels and should be taken at least 2 cm below the liver capsule (Figure 2). Color-coding aids in assessment and allows for averaging over a larger area. In 2-D SWE, several push pulses at different depths are sent down a line by the transducer. These push pulses are summed together creating larger displacements and longer shear-wave propagation distances. Ultrafast imaging is used to follow the shear wave propagation in KHz frame rates. The shear wave velocity is estimated using 2 different spatial points. The 2D SWE image of liver tissue stiffness generated has a low number of push pulses required for the region of interest (ROI), which decreases the probe heating. By positioning one or more ROI in a box called Q-box (Figure 2), quantitative measurements can be performed in 2-D SWE. The Q-box size can vary from 3-700 mm². The mean, standard deviation, minimum and maximum elastography values are then provided in the Q-box (15).

This technique has been shown to have a higher accuracy than TE in assessing mild and intermediate stages of fibrosis. Studies have also shown that 2-D SWE is more accurate than TE in assessing significant fibrosis. Studies have shown that the sensitivity for diagnosing significant fibrosis ($F \geq 2$) varied between 77% and 83 % with a specificity of 82-84%, where as for the diagnosis of cirrhosis, a sensitivity of 81-85 % and a specificity ranging from 61 to 83% were noted (16, 17).

For this technique, the following cutoff values were established in a study by Sporea *et al.* (16) as shown in table 2.

Figure 2. 2D SWE – US image of the liver with 2D SWE. The box in the image with color in it is the area in which the stiffness information is displayed. The color box is placed over the ultrasound image as an overlay. The circles (ROIs – regions of interest) seen within the box are areas where the measurements of the stiffness in the liver are acquired. In this image, 3 ROIs are placed within the color box to produce 3 different values of stiffness within the region.

Table 2: Cutoff values established by Sporea et al using 2D SWE in comparison to TE. (16)

Fibrosis level	Cut off value (kPa)	Sensitivity (%)	Specificity (%)
>F1	7.1	75	78
>F2	7.8	77	83
>F3	8	92	76
>F4	11.5	81	61

The limitations of 2-D SWE are similar to those of pSWE in that there are fewer studies performed on this technique, it is operator dependent, and requires a high level of expertise (18).

II. Strain Elastography:

In contrast to the above-mentioned methods, strain elastography (SE), also known as real time elastography, is a qualitative method to measure tissue elasticity. It is a quasi-static imaging technique in which the operator uses manual compression or cardiovascular pulsation as an excitation method and then meas-

ures the strain response of the tissue to that stimulus. Tissue response is measured and shown as an image either in color or black and white. The fibrotic tissue will displace less than the normal liver parenchyma thus less strain is registered in the images of a fibrotic liver compared to a normal liver (6).

Results are displayed as a color-coded overlay of the gray scale (B-mode) image. Multiple strain values are displayed on a histogram with calculation of the mean strain; standard deviation as well as the percentage of particular color pixels can be generated, which correlate with the degrees of liver fibrosis (Figure

2). The greater the amount of blue pixels seen for example, the greater the liver stiffness (19). The efficacy of this method in the assessment of liver fibrosis and the investigation of liver tumors have been mentioned in a study that have compared strain elastography with point-shear wave elastography (SWE)

and transient elastography (25). Point-SWE and transient elastography have shown better results in predicting significant fibrosis than strain elastography (20). Strain elastography has the following sensitivities and specificities for diagnosing fibrosis as shown in table 3.

Table 3: Sensitivity and specificity of strain elastography for diagnosis of fibrosis as shown in study by Kobayashi et al. (21).

Fibrosis levels	Sensitivity (%)	Specificity (%)
>F2	79	76
>F3	82	81
>F4	74	84

This technique also has some limitations. It is qualitative and not quantitative and hence not easily standardized. Furthermore it is very limited in patients with ascites since the fluid can influence the elasticity of the tissue and in large size patients (22).

Guidelines and Recommendations:

In October 2014 the Society of Radiologists in Ultrasound (SRU) created guidelines for performing UE and interpreting results (5). In addition, the European Federation and Society of Ultrasound in Medicine and Biology created their guidelines on the use of UE in clinical practice in 2013 (23) and an update on the clinical use of liver elastography in 2017 (24). These guidelines and recommendation are briefly described below.

Society of Radiologists in Ultrasound (SRU) guidelines and recommendations

SRU guidelines recommend that elastography is the imaging modality that can be used to

diagnose and distinguish between patients with mild or no fibrosis (Metavir F0 and F1) and those with severe fibrosis or cirrhosis (F3 and F4) without the use of liver biopsy. They also recommend that in a select group of patients, elastography can be used sparing the patient from undergoing an invasive procedure such as liver biopsy. Elastography can also measure disease progression and monitor response to treatment, especially to monitor response to antiviral treatment. Elastography can be combined with lab tests, yielding more accurate results.

They suggest that patients with decompensated cirrhosis can be diagnosed clinically and do not require any diagnostic intervention (5). However, elastography can be helpful in the diagnosis of patients with compensated cirrhosis. They recommend that the USE should provide an interquartile range (IQR)/median value as a quality measure. Following cut off values were recommended to diagnose the various stages of fibrosis as per the Metavir scoring system as shown in table 4.

Table 4: Cut off values for diagnosing various stages of fibrosis as defined by the SRU consensus conference recommendations (5).

Fibrosis stages	Techniques					
	TE		pSWE		2D SWE	
Stage F1 and F2	<7 kPa	<1.5m/s	<5.7 kPa	<1.37 m/s	<7kPa	<1.5 m/s
Stage F3 and F4	>15 kPa	>2.2 m/s	>15 kPa	>2.2 m/s	>15 kPa	>2.2 m/s

The patient's position, equipment and acoustic parameters (e.g. ultrasound machine and transducer frequency) should be mentioned along with equipment calibrations so that the same technique and equipment can be used in follow up studies (5).

EFSUMB guidelines and recommendations:

The purpose of the EFSUMB guidelines was to stress the clinical importance of all forms of imaging modalities in liver elastography by highlighting evidence from meta-analyses and giving practical advice for sonographers about the use of elastography and their interpretations. They recommended the use of TE and SWE to assess the severity of liver fibrosis in patients with chronic viral hepatitis. However no recommendation was provided on the use of strain elastography since the evidence with this approach was still limited (23). In the follow up article, Dietrich et al provide a comprehensive guide about the methodology of acquisition of elastographic images, interpretation, pitfalls and limitations (24).

Technique of performing Ultrasound Elastography of the liver:

A proper protocol is to be followed in order to achieve the highest success with UE, especial-

ly in terms of inter and intra-observer variability. The technique used in our ultrasound lab at the University of Washington is described below.

Patients should be fasting for at least 4 hours prior to the procedure (25). Popescu et al. showed in their study that liver stiffness values were significantly increased after food intake and that ARFI measurements should be taken in fasting conditions (26). The patient should be in supine or 30 degrees left lateral decubitus position, as the intercostal view of the right liver lobe is the preferred approach. The patient is asked to raise the right arm above the head since this position increases the intercostal space allowing for a better view of the liver. Quiet breathing is ideal without performing a deep inspiration or expiration since that leads to a Valsalva maneuver, which can artificially high stiffness in the liver through increased central venous pressure. The elastography imaging and quantification box should be perpendicular to and 2 cm below the liver capsule (Figure 3). This is to avoid near field reverberation artifacts (Figure 4). Reverberation artifacts can also be avoided by applying ample amount of ultrasound gel on the skin surface. The operator should obtain the measurements away from larger vessels or dilated biliary ducts as they

may lead to a misinterpretation of tissue stiffness (25). It is preferable to take a total of 10 measurements in each patient as recommended by the Society of Radiologists in Ultrasound guidelines (5). Choi et al in their study found that the mean stiffness values when 10 measurements were taken were similar to when only 5 measurements were taken,

however the third quartile value and the interquartile/median range was significantly different between the 2 methods (27). They recommend that only 5 measurements can be obtained if the sonographers have had ample training and experience except in patients with fatty liver and patients with liver stiffness values over 10 kPa (27).

Figure 3. Appropriate placement of the Shearwave box in elastography. The box has to be placed at least 2 cm deeper to the liver capsule to avoid reverberation artifacts from the liver capsule interfering with the stiffness measurements.

Figure 4. Reverberation artifacts: Images from pSWE (a) and 2d SWE (b) showing reverberation artifact causing artefactual increase in the stiffness within the liver. Note the stiffness in the liver on pSWE was 2.47 m/s and note the areas of increased stiffness in the superficial part of the SWE box displayed as areas of red color (arrow).

Correlation with liver fibrosis score

Multiple scoring systems have been developed to classify the stages of liver fibrosis based on the gold standard of liver biopsy. These include International Association for Study of the Liver (IASL), Batts-Ludwig, Ishak and the Metavir scoring systems. The Metavir scoring system is the most commonly used and is shown in table 5. In the METAVIR system, fibrosis is staged from Stage F0 to Stage F4, where stage F0 is normal hepatic parenchyma, stage F1 is portal fibrosis without septa formation, stage F2 is enlargement of por-

tal tracts with rare septa formation, stage F3 is formation of numerous septa, and stage F4 denotes cirrhosis in the form of nodular regeneration (9, 28). By comparing the UE imaging results with the histopathology of liver biopsy, correlational cut off scores were created with cutoff levels to differentiate between clinically non-significant and significant fibrosis. These values have been described in the Society of Radiologists in Ultrasound consensus guidelines (5), however values from published literature from each individual manufacturer should be used in clinical practice due to the variability in the methodology of UE.

Table 5: The METAVIR liver fibrosis score (5)

F0	No fibrosis
F1	Mild fibrosis – portal fibrosis without septa
F2	Moderate fibrosis-portal fibrosis and few septa
F3	Severe fibrosis – numerous septa and nodules without cirrhosis
F4	Cirrhosis

Quality assurance:

Operator experience significantly influences the reliability of liver stiffness measurement and this has been well documented in the literature during the use of transient elastography (29). A hundred examinations are considered the minimum required training and training with >500 examinations yields an experienced TE operator (24). A similar agreement has not been reached as to what constitutes an experienced operator for pSWE and 2D-SWE, though EFSUMB guidelines recommend that experience in B-mode US is essential (24). Qualitative and quantitative measures have been developed by the manufacturers to ensure adequate and accurate USE results.

Test objects or ultrasound phantoms have been developed to allow the sonographer to train and reproduce similar results when performing USE on liver tissue. Hence the phantoms used for training should have tissue-mimicking properties to provide realistic and reproducible data sets. Agar and Gelatin based materials have been widely used for this purpose (30). However in clinical setting, performing training on tissue phantoms is suboptimal. Realistically, sonographers rely on specialized trainers to competently train, teach and supervise sonographers on taking adequate images. This could be through in-person hands on training by an application specialist, hands on workshops or training imparted through an in-house super user. Quality assurance, however, has to be an on-

going process and can be performed by these methodologies.

i. Regular retrospective sampling for the datasets to evaluate for appropriateness of the data collected. This can be performed by blinded sampling of 10-20 exams performed over the last 10 months or a particular number of exams performed by each sonographer.

ii. Continuous quality assurance through evaluation of each exam performed by each sonographer by a super user.

Since the continuous quality assurance would be a time consuming process, most centers prefer to perform a retrospective sample based evaluation. Several parameters have been studied that contribute to the quality control of the results obtained. These include presence of artifacts, appropriateness of the box placement, interquartile to median ratio

(IQR/M), the success rate (SR) as well as intrinsic machine quality control parameters (14).

The IQR to median ratio is a statistical number that assesses the quality of the results (Figure 5). An IQR/median ratio value of less than 0.3 or 30% suggests that the set of data is adequate. The IQR helps the radiologist to monitor the technique applied and the equipment quality for possible improvement (8). According to Castera et al. (31), at least 10 measurements should be taken with a $\geq 60\%$ success rate of the images taken (SR = the ratio of the number of successful measurements over the total number of acquisitions) otherwise values are unreliable (31). If greater than 10% of the images have IQR/median ratio $>30\%$, this should be flagged and appropriate training should be provided to that particular sonographer.

Figure 5. IQR/median ratio: IQR to median ratio is a statistical number that assesses the quality of the results. Arrows in the image point to the IQR/median ratio which is high in this case of 44 and 41% suggesting inappropriate images.

Other quality indicators which should be used on a case-by-case basis by the operator when acquiring the images include a standard deviation of less than 30% (32), quality indicator, confidence map etc. Various vendors have implemented proprietary validation systems: The Aplio 500 system from Toshiba can indicate whether an elasticity measurement was successful or not using its propagation mode. In this system, one can actually see whether

or not the quality of the shear-wave propagation is adequate, and then measure where the propagation lines occur mostly within a particular region of interest. Philips Medical Imaging has introduced the ElastQ imaging technique as a real time shear elastogram with a confidence map provided to evaluate the reliability of the shear wave elastograms within the particular image (Figure 6).

Figure 6. Confidence map: Confidence map helps evaluate the reliability of the shear wave elastograms within the particular image. Uniform green indicates 100% reliability – as displayed on the color scale on the right hand side of the image. Areas of red and yellow indicate lower reliability.

Technology is evolving throughout time; machines are being updated to give more accurate results.

Pitfalls

The main limitations in ultrasound liver elastography are technical challenges (33). It is operator as well as patient dependent. As an example velocities obtained from the left lobe are higher compared to right lobe measurements. This is a technically confounding factor. Since the left hepatic lobe is more prone to compression by the US probe, the stomach

or the heart, selection of this lobe would lead to an artificial increase in the velocity of the acoustic waves. Thus intercostal measurement in the right lobe is the preferred approach.

The inclusion of non-parenchymal liver tissue within the region of interest such as the liver capsule, blood vessels, falciform ligament, gallbladder wall or bile duct is another technical confounder since these structures are relatively stiff compared parenchyma and will lead to abnormally elevated velocity measurements (Figure 7).

Figure 7. Artifact from blood vessel: Confidence map (a) and 2D SWE image (b) show an area of lack in color in the lower left hand corner of the SWE box (arrow) which indicates lack of information due to the blood vessel in this region. Confidence map (a) shows this region as an area with red color due to the very low reliability in this region and a measurement should not be taken in this region.

Measurement depth also contributes to velocity determination. An ideal depth is 2–7 cm from the liver capsule in order to avoid reverberation artifacts when the measurements are superficially taken. Deeper measurements may suffer from acoustic penetration issues.

Patient related factors can also distort sonographic results. Movement during respiration can lead to inaccurate measurements. A mid expiration breath hold is ideal. Deep inspiration can increase stiffness measurements due to underlying Valsalva effects. Other biologic factors that can alter elastography results include inflammation, hepatic congestion (CHF), postprandial state, diurnal variation, and alcohol.

According to Castera et al. a 5-year prospective study of 13,369 examinations showed that the following factors were the main factors for increased liver stiffness measurement: operator experience fewer than 500 examinations, patient age greater than 52 years, female gender, type 2 diabetes and a body mass index (BMI) greater than 30 kg/m, particularly with central obesity (31).

Conclusion:

Liver elastography is a noninvasive imaging modality that is now favored in the diagnosis and prognosis of liver fibrosis. However, the UE studies have to be performed by operators with adequate training and significant research is lacking in this field. International societies such as EFSUMB and SRU continuously update their consensus guidelines regarding the use of UE to make it widely acceptable and relatively easy to use in clinical practice. There is persistent improvement in developing standardized methods for measuring liver stiffness as well as technical improvement in the machines. In the near future, ultrasound liver elastography may become the standard of care for the diagnosis of liver fibrosis in clinical practice.

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