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" Role of Ultrasound and Magnetic Resonance Elastography in Evaluation of Hepatic Fibrosis in Patients with Viral Hepatitis B And C: A Clinical Review "

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ABSTRACT:

Histopathology and degree of hepatic fibrosis (HF) are major factors in chronic liver disease therapy and prognosis. According to certain reports, HF contributes to the development of cirrhosis, hepatocellular carcinoma, and portal venous hypertension, which in turn increases the risk of death and morbidity for patients. Liver biopsies have long been regarded as the golden standard for diagnosing HF. However, there are uncommon but serious risks associated with liver biopsies, rendering the procedure both invasive and costly. Over- or understaging of HF can also occur due to sampling mistakes and intra- or interobserver heterogeneity. Additionally, liver biopsy might not be the best way to track the development of illness due to its intrusive character. Efforts to create noninvasive techniques for HF staging that are easy, cheap, and accurate have therefore been substantial. The quest for noninvasively diagnosing and staging HF has recently led to the development of several promising novel approaches. A number of stiffness imaging techniques have been extensively studied, including those based on ultrasonography (US) and magnetic resonance (MRE) elastography, for the purpose of measuring liver stiffness (LS).

Key words: Ultrasound elastography, Magnetic resonance elastography, Non-invasive staging of liver fibrosis.

INTRODUCTION

Chronic liver illnesses caused by hepatitis viruses C or B, ethanol addiction, or non-alcoholic steatohepatitis (NASH) are common in daily practice. In everyday hepatology, also autoimmune hepatitis and primary biliary cirrhosis are diagnosed [(1)]. Hepatic fibrosis, cirrhosis, portal hypertension, and hepatocellular cancer can result from chronic liver disease. Repetitive damage disrupts the healing response, generating aberrant connective tissue synthesis and deposition in the liver. It is found in many chronic liver disorders. Early detection of liver fibrosis may reverse it. Staging liver fibrosis helps prognosticate, track progression, and evaluate treatment [(2)]. The current liver fibrosis reference test is liver biopsy. Patient acceptance is challenging because to its high cost and modest likelihood of serious consequences. Its accuracy is also disputed due to sampling variability caused by tiny hepatic samples and liver fibrosis heterogeneity [(3)]. Chronic liver illnesses afflict millions of people globally, making noninvasive liver fibrosis testing difficult. Numerous studies show that fibrosis is dynamic and reversible with adequate treatment [(4)]. Treatment of various types of hepatitis, and other chronic liver conditions reduces histologic fibrosis and improves clinical symptoms. The discovery of noninvasive liver fibrosis indicators is crucial for assessing disease prognosis and therapy response [(5)].

Several noninvasive liver fibrosis staging methods include biochemical testing and imaging. APRI, FibroTest, and other composite scores or serum markers of fibrosis such as hyaluronic acid are biochemical diagnostic tools. The effectiveness of these diagnostic methods procedures is disputed [(6)].

Ultrasound and MR elastography (MRE) can measure liver viscoelasticity to diagnose fibrosis non-invasively. Both methods are highly accurate at detecting cirrhosis and excluding severe liver fibrosis[(7)]. Ultrasonography (US) is perfect for noninvasive diffuse liver disease assessment due to its inexpensive cost and broad availability. Traditional B-mode ultrasound detects advanced cirrhosis but not fibrosis. Elastography can detect fibrosis. The major methods for direct and indirect liver stiffness quantification include transient elastography (FibroScan), shear-wave (2D-SWE), and acoustic radiation force impulse (ARFI) imaging. The most popular technology is transient elastography[(8)].

Magnetic resonance (MR) elastography quantifies tissue viscoelasticity, which changes under pathologic situations, and is quickly developing. The approach may replace liver biopsy for the purpose of staging and monitoring hepatic fibrosis in chronic liver disease patients. MR

elastography employs low-frequency mechanical waves to generate shear stresses within the tissue of interest, however the acquisition and postprocessing procedures vary by site. Motion-sensitive MR imaging sequences assess displacement fields. From these displacement fields, tissue viscoelastic shear characteristics are investigated[7].

The purpose of this paper is to synthesize the current knowledge on the use of ultrasonography (U/S) and magnetic resonance elastography (MR elastography) as noninvasive methods or evaluating hepatic fibrosis in individuals infected with hepatitis B and C viruses.

ULTRASOUND ELASTOGRAPHY:

Elastographic methods utilizing ultrasound waves for liver fibrosis evaluation can be categorized as follows (9):

1. **Strain Elastography** (quasi-static elastography).
2. **Shear waves Elastography**:
   a. Transient Elastography (FibroScan).
   b. Point-shear waves Elastography – Acoustic Radiation Force Impulse (ARFI).
   c. Real-Time Shear Waves Elastography – [Supersonic Imagine, Aixplorer system].

1. *Strain elastography*

One of the most prominent commercial techniques, strain elastography, applies continual stress to the tissue being studied. An external mechanical force or an internal endogenous force applies pressure to the tissue, and numerous photos are taken to capture the delay between successive photographs in the region of interest. To create reproducible elastograms, deformation strength and duration must be visually regulated and compressed at least twice [10]. This method is simple, but the uncertain stress distribution prohibits quantitative target zone stiffness estimation. The investigator's skill in finding the proper angle to apply enough compression strength to eliminate artifacts improves the inspection. The operator immediately applies stress, limiting its use to the superficial organs such as the breast or thyroid [11].

2. *Transient elastography (TE):*

TE is a fast, easy-to-use technology with instant results and good consistency[12]. TE measures organ stiffness by using mechanically generated low-frequency (50 Hz) shear waves that travel through tissue at a speed directly related to tissue elasticity, moving slower in softer tissues and faster in stiffer areas (13). TE fails in fewer than 5% of cases,

primarily in obese individuals. The technique has been extensively validated for chronic hepatitis C, where it can detect substantial fibrosis as well as blood indicators. In addiction, TE and serum indicators improve diagnostic accuracy, allowing most chronic hepatitis C patients to avoid liver biopsy. TE may have prognostic significance in early cirrhosis detection and can monitor fibrosis regression and progression (14), although additional supporting data is needed.

3. Acoustic radiation force impulse (AFRI):

ARFI imaging offers real-time quantitative and qualitative measurements, including elastograms and tissue parameters like peak displacement, recovery time, and time to peak displacement, complementary to conventional US[15]. After mechanically excitating the tissue, a localized impulsive acoustic radiation force propagates the shear wave propagating away from the excitation. Thus, the machine generates the elastogram by measuring tissue reaction to excitation-induced displacement. ARFI is one-dimensional and lacks real-time measurements and tissue elasticity maps. Only the region of interest average is calculated [15,16].

4. Two-Dimensional Shear-Wave Elastography (2D-SWE)

2D-SWE is an ultrasound-based (US) method for non-invasive assessment of liver fibrosis that is embedded in US machines and uses focused ultrasonic beams to interrogate tissue with acoustic radiation force impulses and capture shear wave propagation in real time. In the region of interest (ROI), a color-coded overlay on a B-mode image shows elasticity and quantifies liver stiffness (LS)[17]. Herrmann et al. conducted an individual patient data-based meta-analysis comparing 2D-SWE to liver biopsy in 400 CHB patients. The AUROC of 2D-SWE was 0.91 for severe fibrosis and 0.95 for cirrhosis. Meanwhile, Zeng et al. observed a strong correlation between 2D-SWE and TE for assessing liver fibrosis. In a cohort of 257 CHB patients with histological diagnoses, Spearman's rank correlation coefficients were 0.52 for stage F0 ($p < 0.001$), 0.68 for F1, 0.78 for F2, 0.67 for F3, and 0.75 for F4 ($p < 0.001$). The AUROC values for 2D-SWE and VCTE for staging F2–4, F3–4, and F4 were 0.88–0.93 and 0.85–0.91, respectively, with no substantial difference observed between these imaging tests[19]. In a metaanalysis by Dong et al., based on 72 studies, including 2D-SWE and MRE outperformed serum biomarkers in the dedication of significant and advanced cirrhosis, respectively, with AUROCs of 0.89 and 0.97, 0.95 and 0.97, and 0.94 and 0.97, respectively. APRI and FIB-4 exhibited AUROCs of 0.76 and 0.75, 0.74 and 0.77, and 0.77 and 0.82, respectively [20]. A meta-analysis of 11 trials involving 2,623 CHB patients found that 2D

SWE, with a mean threshold of 7.91 kPa, demonstrated 88% sensitivity, 83% specificity, and an AUROC of 0.92 for diagnosing severe fibrosis. [21].

MAGNETIC RESONANCE ELASTOGRAPHY (MRE)

Using magnetic resonance elastography techniques (MRE) assesses fibrosis in chronic liver disease patients using MRI. Over the previous 15 years, tertiary clinical research facilities have had more MRE[22]. MRE has gained growing validation as an alternative to liver biopsy for staging fibrosis in MASLD clinical trials [23]. MRE outperformed APRI and AST/ALT ratio in a brief study involving 63 patients with CHB for severe fibrosis and cirrhosis indicated by biopsy[24]. In a cohort of 63 CHB patients confirmed by biopsy, MRE outperformed DWI in detecting substantial fibrosis (more than F2), advanced fibrosis (more thanF3), and cirrhosis (F4)[25]. MRE was tested for reliability and validity in CHB fibrosis diagnosis by Ichikawa et al. MRE outperformed serum fibrosis indicators in staging biopsy-proven liver fibrosis in 73 CHB patients. Two observers had outstanding MRE interobserver agreement[26].

RECOMMENDATIONS FOR EVALUATION OF CHRONIC LIVER DISEASE

Many clinical settings use noninvasive liver fibrosis diagnostics. Most serologic marker and radiologic test studies have focused on fibrosis staging in chronic viral hepatitis patients. We think radiologic hepatic fibrosis staging is promising. Ultrasound and magnetic resonance elastography are used. The best researched radiologic approach for staging hepatic fibrosis is ultrasound-based transient elastography. Local availability will determine tests. Each approach has risks and limitations that the radiologist must be aware of. Since the patient may be unwilling to undergo liver biopsy, a noninvasive test should be used first. TE or MRE imaging can aid if these tests anticipate cirrhosis or mild fibrosis. If noninvasive testing is inconclusive, a liver biopsy may be needed for stage confirmation. If the patient has no or minimal fibrosis and refuses antiviral medication, longitudinal elastography imaging to identify liver stiffness rise is preferred[27].

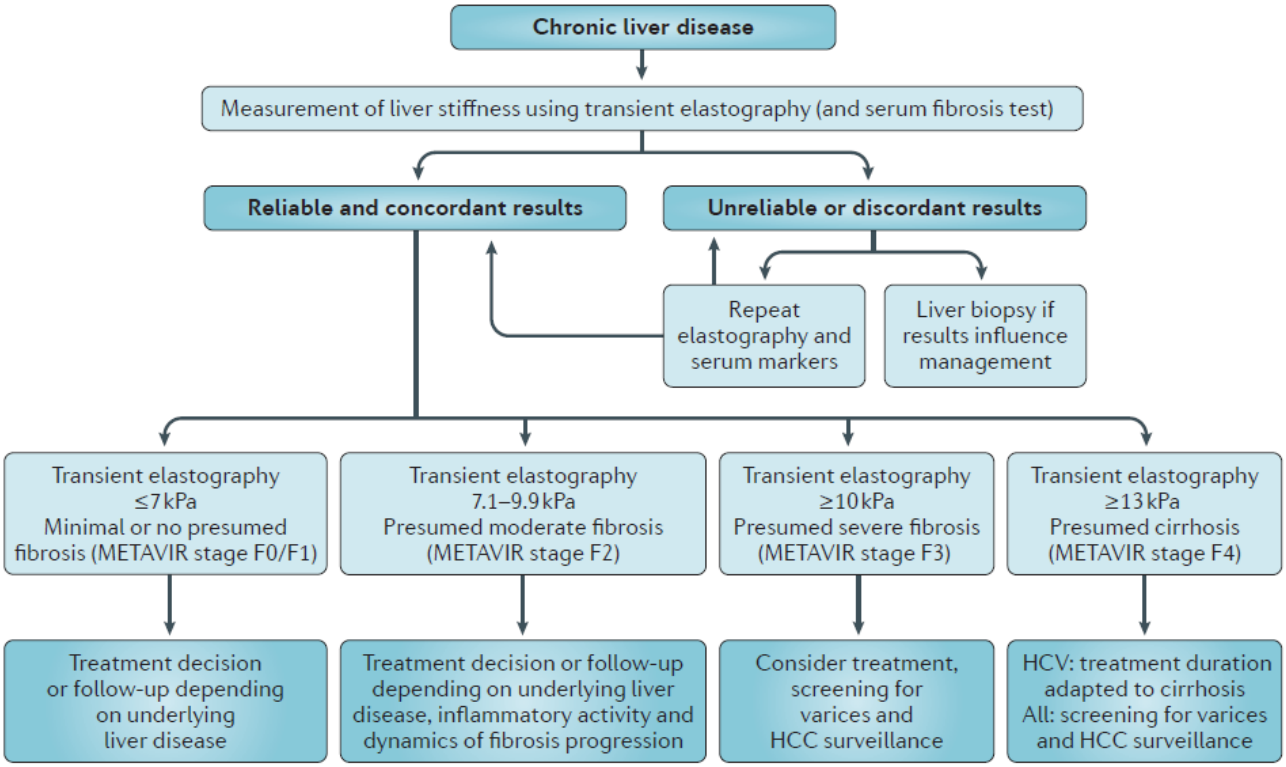

Figure 1 | An example of a diagnostic algorithm for interpreting transient elastography results in the assessment of liver disease.

CONCLUSION:

By assessing liver viscoelasticity, ultrasound elastography and MRE can diagnose liver fibrosis non-invasively. Both methods are accurate at detecting cirrhosis and excluding severe liver fibrosis. Currently, ultrasound uses transient elastography (FibroScan), shear-wave (2D-SW) elastography and acoustic radiation force impulse (ARFI) imaging to quantify liver stiffness directly and indirectly. The most popular technology, transient elastography, is unreliable 15.8% of the time. It's inaccurate for intermediate fibrosis, fails with obesity and small rib space, and generates false positives with inflammation and congestion. A probe designed for obese people may eliminate the need for technically limited exams. MRE has good reproducibility, but imaging operations are automated, thus operators are not needed. Obesity and rib interspace width do not alter MRE.

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