FibroScan (Vibration-Controlled Transient Elastography): Where Does It Stand in the United States Practice

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With widespread screening and increasingly effective treatments for patients with viral hepatitis as well as the increasing prevalence of nonalcoholic fatty liver disease, the population presenting to the care of gastroenterologists and hepatologists is certain to increase. Assessment of advanced liver disease is traditionally invasive and expensive. Vibration-controlled transient elastography, commonly delivered by the FibroScan device, is an option recently approved by the Food and Drug Administration for the noninvasive assessment of liver disease at the point of care. Herein, we review the promise and pitfalls of vibration-controlled transient elastography with the aim of providing clinicians with a framework to interpret its results and apply this technology to the changing needs of our patients.

Keywords: Liver Disease; Cirrhosis; Fibrosis; Hepatitis; Nonalcoholic Fatty Liver Disease.

As liver fibrosis progresses to cirrhosis, portal hypertension, and their attendant complications, there is a significant increase in morbidity and mortality. Key elements in the diagnosis of fibrosis and risk stratification thereafter rely on invasive tools such as liver biopsy to stage fibrosis and endoscopy to screen for varices. These tests are expensive and associated with risk. Furthermore, in the context of widespread screening for hepatitis C (HCV) and hepatitis B (HBV) and increasingly effective treatments for patients with viral hepatitis as well as the increasing prevalence of nonalcoholic fatty liver disease (NAFLD), the population presenting to the care of gastroenterologists and hepatologists will surely increase. Now more than ever, there is a critical need for a noninvasive, safe, quick, inexpensive, and reliable tool to evaluate these patients at the point of care.

Vibration-controlled transient elastography (VCTE) commonly delivered by the FibroScan device (Echosens, Paris, France) is an option recently approved by the Food and Drug Administration for clinicians facing this problem. Herein we will review the promise and pitfalls of VCTE in the American clinical setting.

How It Works

VCTE works by measuring shear wave velocity. In this technique, a handheld probe is placed in the intercostal space overlaying the right hepatic lobe. The velocity of returning shear waves, measured at a depth of 25–65 mm, is converted into a liver stiffness measurement (LSM) by using Hook’s law. The resistance to deformation (ie, stiffness) in a given material (in this case a liver) under stress (a shear wave) is expressed by Young’s modulus in kilo-pascals (kPa). VCTE uses the formula \( E = 3pV^2 \), which is based on Hook’s law, where \( E \) is Young’s modulus, \( p \) is mass density (assumed to be 1000 kg/m\(^3\)), and \( V \) is the velocity of the shear wave. \(^2\) (Figure 1). The LSM obtained from a given VCTE exam is the median value of at least 10 successful measurements. Success is based on 2 criteria, the quality of the shear wave emitted by probe and the quality of the strain rate image used to estimate the stiffness. LSM is translated into clinically meaningful information with reference to evidence-based cutoffs pertinent to the patient’s underlying condition. However, these cutoffs are arbitrary in different populations, and VCTE does not stage fibrosis but rather stratifies risk and correlates very well with fibrosis.

Keep These Limits in Mind

There are some consistent themes regarding VCTE test performance across etiologies of liver disease. Because of the mechanism of data acquisition, any process that interferes with the depth of the liver examined in relation to the probe may affect measurement success. For example, ascites precludes the applicability of VCTE but is less critical to clinicians assessing patients for advanced liver disease. Important LSM confounders include obesity, inflammation, cholestasis, congestion, and food intake (Figure 1).

The reproducibility of VCTE has been examined by multiple groups first in 2007 by Fraquelli et al. \(^3\) This

Abbreviations used in this paper: ALT, alanine aminotransferase; AUROC, area under the receiver operating characteristic curve; BMI, body mass index; CAP, controlled attenuation parameter; CI, confidence interval; HBV, hepatitis B virus; HCV, hepatitis C virus; LSM, liver stiffness measurement; NAFLD, nonalcoholic fatty liver disease; NASH, nonalcoholic steatohepatitis; NPV, negative predictive value; OR, odds ratio; PBC, primary biliary cirrhosis; PPV, positive predictive value; VCTE, vibration-controlled transient elastography.
group studied 800 VCTE examinations, 2.4% of which yielded indeterminate results. Factors significantly associated with reduced interobserver agreement included increased body mass index (BMI) (25 kg/m² or greater), steatosis, and low fibrosis stages. Similarly, in a study of healthy subjects, the rate of VCTE failure (0 valid acquisitions) increased with BMI, reaching an 88% failure rate for BMI greater than 40 kg/m².4 Confirming these trends, Castera et al5 showed how in their prospective database of 13,369 VCTE examinations, rates of failure and unreliable examinations (less than 10 valid acquisitions or success rate <60% or interquartile range less than 30% of median value) occurred in 3.1% and 15.8% of exams, respectively. Failure was most associated with BMI greater than 30 kg/m² (odds ratio [OR], 7.5) and operator experience of fewer than 500 exams (OR, 2.5). The same applied for unreliable exams: BMI greater than 30 kg/m² (OR, 3.3) and operator inexperience (OR, 3.1).5

Beyond obesity, essentially any process that alters hepatic viscoelastic properties can affect LSM. Hepatic inflammation, acute or chronic, can lead to falsely elevated LSM.6–9 Whereas bland steatosis itself does not affect VCTE, steatohepatitis does.10 Extrahepatic cholestasis, passive cardiogenic congestion or central venous hypertension, amyloid deposition, and meal ingestion (at least in cirrhotic patients) have each been shown to influence liver stiffness as measured by VCTE.11–17

Finally, operator experience may play a role. In general, operators need to have done more than 100 examinations, perhaps more than 500, before operator experience is no longer a confounding variable.5,18

In summary, there are several factors that must be addressed to ensure the quality of information obtained from VCTE. We currently recommend at least 10 measurements of liver stiffness with an interquartile range of <0.3 and a success rate greater than 60%. Some authorities recommend that at least 70% of measurements be valid, but this has never really been studied and compared with liver biopsy. Patients should fast at least 3 hours. Consideration and correction should be made for alanine aminotransferase (ALT) levels above 100 IU/L.

Finally, we recommend a history and physical exam to assess for evidence of known confounding variables.

Noninvasive Determination of Fibrosis

The long-held gold-standard determinant of hepatic fibrosis is the liver biopsy. It is an imperfect standard with many disadvantages. It is an invasive procedure requiring significant resources including highly trained operators, nursing for observation, and expert pathology examination. It is associated with potentially significant risk ranging from pain to hemorrhage.19 Finally, liver biopsy samples represent roughly 1/50,000th of the liver, which is naturally heterogeneous.20 Sampling error is compounded further by the poor interobserver agreement often associated with histologic interpretation, with stage discrepancies occurring in up to 58% of biopsies (depending on degree of fibrosis).21,22 In the era of increasingly effective antiviral therapies for our patients with hepatitis, the magnitude of all of these problems—risk, cost, and unreliability—will only grow, underscoring the need for convenient noninvasive diagnostics.

VCTE’s advantages over biopsy are several. It is safer and less expensive and assesses a far larger volume of hepatic parenchyma. By and large, the data show that VCTE, not unlike serologic markers of fibrosis, best discerns the extremes of fibrosis, F0/F1 versus F4. Importantly, independent of etiology, VCTE can diagnose cirrhosis with an area under the receiver operating characteristic curve (AUROC) of 0.94 (95% confidence interval [CI], 0.93–0.95).23 The burgeoning field of
noninvasive tests for advanced liver disease is beyond the scope of this review and is discussed elsewhere. In truth, these tests are mutually supportive and often function as confirmative tests (Figure 2).

**Detecting Fibrosis in Patients With Hepatitis C**

Chronic HCV infection is both common and an important determinant of public health in the United States. The morbidity of HCV infection is almost completely related to the development of cirrhosis. Because of the Centers for Disease Control’s recommendation to screen patients born between 1945 and 1965 for HCV and the rising tide of effective anti-HCV therapies, we should anticipate a major influx of patients on the order of 1 million who are seeking care for HCV. VCTE is an excellent option for these patients, potentially solving the cost and risk of biopsy assessment while lowering patient-related hesitation toward diagnostic testing. Accordingly, it is critical that clinicians are able to interpret VCTE results within the bounds of its limitations.

Traditionally, fibrosis in HCV has been staged by using a variety of scoring systems; the 2 most commonly used are the METAVIR and Ishak scores. These scores were designed to stage fibrosis from none through portal fibrosis, bridging fibrosis, and cirrhosis. Their value was most significant for clinical trials, helping to prioritize patients with portal or more advanced fibrosis who needed treatment and especially in the interferon era when treatment side effects limited patient acceptability, response rates were lower, and many patients with mild disease wished to defer treatment. Now the efficacy of new treatments approaches >90% sustained virologic response, and the increased tolerability of interferon-free regimens has made exact staging of disease less important. Thus for the clinician today, exact staging of disease is less relevant. Clinicians should use new technologies to identify patients with mild or no fibrosis and therefore little chance of liver-related events from those with more advanced disease. In this new paradigm, stage should not determine treatment eligibility but can be used in resource-poor countries to determine priorities for therapy. The most important knowledge derived from staging fibrosis in HCV is identifying those patients with bridging fibrosis and especially cirrhosis who should be screened for varices and hepatocellular carcinoma. Accordingly, we would consider the most critical step of staging fibrosis as the exclusion of cirrhosis with the greatest negative predictive value (NPV).

We therefore use VCTE as the first critical point-of-care test to exclude the presence of cirrhosis. First described by Ziol et al in their prospective study of VCTE paired with biopsy in 327 patients with HCV, optimal LSM cutoffs for F2 or greater and F4 (cirrhosis) were 8.7 and 14.5 kPa, respectively. However, subsequent studies have determined other cutoffs. That same year, Castera et al reported on 183 consecutive HCV patients with cutoff values of 7.1 kPa for ≥F2, 9.5 kPa for ≥F3, and 12.5 kPa for F4. Two years later, Fraquelli et al identified the following cutoffs in an Italian population: 7.9 kPa for ≥F2, 10.3 kPa for ≥F3, and 11.9 kPa for F4. Arena et al found that patients with less than 12 kPa clearly indicated the absence of cirrhosis, whereas a cutoff of greater than 18 kPa clearly indicated cirrhosis. Cardoso et al found that cutoff of 7.1 kPa has an 88%
positive predictive value (PPV) for significant fibrosis, whereas 12.5 kPa has an NPV of 98% for cirrhosis. At the National Institutes of Health in their experience with VCTE, 7 patients with false-negative biopsies and clinical cirrhosis were correctly identified by an LSM cutoff of 13.1 kPa. In our hands, a conservative stiffness cutoff of 7.3 kPa distinguishes American patients without significant fibrosis from those who may with excellent NPV. We recently reported results of the U.S. cohort study that included our experience with more than 900 American patients with chronic viral hepatitis with a mean BMI of 27.3 kg/m². In this population, the cutoffs for F3 (bridging) fibrosis were 8.5 and 8.6 kPa for patients above and below the median BMI. The cutoffs for F4 (cirrhosis) were 17.1 and 10.4 kPa for patients above and below the median BMI, with respective AUROC of 0.91 and 0.90.

It is important to contextualize cutoffs for advanced fibrosis by accounting for the viscoelastic properties of chronic inflammation. The ALT level should be known at the time of VCTE. It has been long known that inflammation, acute and chronic, confounds LSM in patients with HBV and mixed viral hepatitis populations. In 2012, we reported in this journal that in a group of patients with biopsy-proven F0-F2 fibrosis, LSMs suggestive of cirrhosis by 3 different cutoffs were obtained in patients with high-grade histologic inflammation as well as in those with high ALT. By using the most conservative cutoff, levels of ALT greater than 80 and 120 IU/L suggested a “cirrhotic” liver with ORs of 3.84 and 4.10, respectively. These findings are further supported by the decrease in liver stiffness that patients experience during antiviral therapy for HCV.

Detecting Fibrosis in Patients With Hepatitis B and Treatment Considerations

Experience with VCTE in HBV has lagged behind HCV until recently. From several French groups with known VCTE expertise came some of the strongest early data. led a multicenter group that prospectively evaluated 202 patients with paired biopsy and LSM. The AUROCs were 0.81 for ≥F2 and 0.93 for F4. Their optimal LSM cutoff values were 7.2 and 11.0 kPa for ≥F2 and F4, respectively. By using cutoffs of 11.0 and 18.2 kPa, the respective PPVs/NPVs for cirrhosis were 38%/99% versus 67%/96%. The performance of these cutoffs has been confirmed in others’ hands. A recent meta-analysis of published studies comprising 2772 patients evaluated the performance of VCTE in chronic HBV. Fourteen of 18 studies included in this analysis were strictly HBV exclusive. Cutoffs for F2 (or greater), F3-F4, and F4 were 7.9 kPa, 8.8 kPa, and 11.7 kPa, respectively. An LSM of 11.7 kPa had a sensitivity of 84.6% and a specificity of 81.5% for the detection of cirrhosis.

In HBV as in HCV, there is the potential for a false-positive increase in measured liver stiffness as a result of necroinflammatory activity. One of the first signals that chronic inflammation, reflected by ALT level, affected VCTE reliability in HBV came from the study by of 297 consecutive Italian patients with chronic HBV. Among patients with identical fibrosis stage, those with elevated ALT had higher LSM. LSM also increased 1.3-fold to 3-fold during HBV flares detected during evaluation. This later finding is readily reproducible, most starkly in a group of 12 noncirrhotic patients with acute HBV. Nine of their patients (75%) had LSM greater than 11.9 kPa on presentation, suggesting cirrhosis. At week 24 after the resolution of the acute hepatitis, none had LSM greater than 11.9 kPa. To determine the relative contribution toward liver stiffness of each level of viral activity, Fung et al prospectively evaluated 157 patients in Hong Kong. VCTE was performed in healthy subjects as well as in those with occult HBV (positive viral load, negative surface antigen), active HBV (positive surface antigen and viral load), and HBV-cirrhosis. The respective LSMs of these groups were 4.6 kPa (2.0–7.1), 4.2 kPa (3.4–6.9), 8.7 kPa (3.6–44.3), and 33.8 kPa (11.9–75). Clearly, ALT can confound VCTE’s PPV and must be considered when interpreting its results.

Because guidelines explicitly base HBV treatment recommendations on inflammation (ALT), viral load, and often histology, the confounding effect of ALT has an added dimension of importance. Accordingly, suggest an ALT-based algorithm for the use of VCTE in HBV. On the basis of their experience with 161 Chinese patients undergoing paired VCTE and biopsy, this group suggests that when patients have a normal ALT score above or below VCTE cutoffs for significant fibrosis (in their study 5 kPa or less versus 9.0 kPa or greater), one can make treatment decisions without a liver biopsy, reserving biopsy for patients with indeterminate results (eg, 6–9 kPa). However, for patients with elevated ALT (greater than the upper limit of normal), liver biopsy was used in an expanded indeterminate zone of 7–12 kPa. In clinical practice, one could substitute biopsy for serologic assessment of fibrosis (Figure 2).

Detecting Fibrosis in Patients With Nonalcoholic Fatty Liver Disease

NAFLD is prevalent in 46% of Americans and nonalcoholic steatohepatitis (NASH) in more than 12%, and the rates of both are increasing significantly globally. Because of the size of the population with NAFLD, there are legitimate public health concerns regarding the cost and risk of biopsy assessment for advanced disease. Biopsy is used to stage fibrosis and to differentiate simple steatosis from NASH, and novel scoring systems proposed to diagnose NASH are based on steatosis, inflammation, and apoptosis. Because VCTE cannot reliably differentiate the histologic features of NASH, it should be realized that VCTE can only be used to determine degree of fibrosis or presence of...
cirrhosis and not to diagnose or rule out NASH. The main problems affecting VCTE in NAFLD are an increase in failed or corrupted exams proportional to BMI or potentially due to confounding by steatosis. The most common reason for failure of VCTE is a BMI greater than 30 kg/m², where the reported failure rate is 22%–25%.\(^{5,48}\,49\)

The effect of steatosis on liver stiffness is controversial, but several studies have explored this relationship. For example, Gaia et al.\(^{50}\) found that NAFLD patients with F3 and severe steatosis had lower LSM values, similar to those of patients with F1 and mild steatosis. By using a cutoff of 8 kPa, VCTE underestimated the fibrosis stage in 75% of patients with F3 and severe steatosis. However, by using a similar cutoff of 8.75 kPa for \(\geq\) F3 fibrosis, Petta et al.\(^{51}\) found a false-negative rate of 24%. In the largest study, Wong et al.\(^{48}\) prospectively enrolled 246 consecutive patients from centers in China and France, and by using a 10.3 kPa cutoff, they found 99% NPV and 46% PPV for the diagnosis of cirrhosis.

The so-called XL probe was designed to overcome chest-wall adiposity and improve VCTE test characteristics in an obese population. There is reproducible evidence that it works. Compared with the M probe, the XL probe has a larger tip diameter, lower central frequency, and greater vibration amplitude. Critically, it assesses liver stiffness at a greater depth (3.5–7.5 cm). Obese patients can experience similar rates of successful LSM when this modified probe is used.\(^{52}\)–\(^{55}\) For instance, Myers et al.\(^{54}\) have shown in a population of 276 patients with chronic liver disease and BMI \(>\) 28 kg/m² that the failure rate was significantly lower with the XL probe than with the M probe (1.1% versus 16%, \(P < .00005\)). However, 2 issues remain. First, even with the XL probe, although to a lesser degree than the M probe, VCTE reliability decreases for patients with BMI greater than 30 kg/m².\(^{53}\) Also, unreliable results are still observed with the XL probe in 25% of cases compared with 50% of cases with the M probe (\(P < .00005\)).\(^{54}\) Indeed, the XL probe and histology are discordant in as many as 9% of patients with BMI greater than 35 kg/m².\(^{49}\) Second, the XL probe may generate lower LSM than the earlier M probe in the same patient, suggesting that disease-specific fibrosis cutoffs may need to be lower in XL probe exams. Multiple investigators have found that LSM by the XL probe is lower than by the M probe by as much as \(1.7 + 2.3\) kPa.\(^{49,54}\) Thus, although these novel probes improve the reliability of VCTE in obese patients, further research is needed to determine BMI cutoffs for both reliability and accuracy.

### Alcoholic Liver Disease

Especially in its earlier stages, alcoholic liver disease is characterized by sinusoidal fibrosis, steatosis, and significant inflammation; thus, LSM by VCTE is susceptible to confounders. Abstinence can dramatically affect VCTE results. Reproducibly, abstinence is associated with a roughly 4.9 kPa decrement in LSM.\(^{56}\)–\(^{58}\) Significantly decreased LSM can be seen even after 7 days of abstinence. LSM decreased from 7.2 to 6.1 kPa in 7 days of sobriety in one study, resulting in a reduction in the estimated fibrosis stage in 32 patients (23.3%).\(^{59}\) Nahon et al.\(^{60}\) examined the role of VCTE in a French population of 147 patients with alcoholic liver disease undergoing paired LSM and biopsy, 53.7% of whom had cirrhosis and 28.7% of whom had moderate to marked alcoholic hepatitis on biopsy. By using optimal cutoffs of 12.96 and 22.7 kPa, the AUROCs were 0.94 and 0.87 for the diagnosis of advanced fibrosis and cirrhosis, respectively. Excluding patients who were actively drinking, Mueller et al.\(^{57}\) found that a cutoff of 12.5 kPa had an AUROC of 0.91 for F4 fibrosis. Therefore, when using VCTE to evaluate patients with alcoholic liver disease, the clinician must take into account both current drinking habits and the presence of active alcoholic steatohepatitis.

### Biliary Disease

Experience with VCTE in the setting of primary biliary liver disease is limited. Extrahepatic cholestasis is known to increase liver stiffness for all patients.\(^{11}\) Corpechot et al.\(^{61}\) were the first group to examine the role of VCTE in primary biliary cirrhosis (PBC) and primary sclerosing cholangitis. In their multicenter prospective study, 73 patients with PBC and 28 with primary sclerosing cholangitis underwent paired VCTE and liver biopsy. The AUROCs for LSM predictions of fibrosis stage were 0.92 and 0.96 for \(\geq\) F2 and F4, respectively. Optimal stiffness cutoff values for advanced fibrosis (F3-F4) and cirrhosis were 9.8 and 17.3 kPa, respectively. An LSM of 9.8 kPa was associated with OR of 72.7 (95% CI, 11.0–1488.2) for the presence of advanced fibrosis.\(^{62}\) Friedrich-Rust et al.\(^{63}\) compared VCTE with magnetic resonance spectroscopy and serum markers in a group of 45 Germans with PBC with paired liver biopsies. VCTE provided superior correlation with histology: AUROCs of 0.74 and 0.95 for \(\geq\) F2 and F4 fibrosis, respectively. Recently, Corpechot et al.\(^{62}\) examined the role of VCTE in the longitudinal evaluation of patients with PBC treated with ursodeoxycholic acid. They found an overall progression rate of 0.48 ± 0.21 kPa/year but did not detect any progression in METAVIR stages.

### Vibration-Controlled Transient Elastography for Prediction of Liver-Related Outcomes

It is intuitive that increasing liver stiffness reflects increasing portal hypertension. VCTE can predict significant portal hypertension (hepatic venous pressure gradient \(\geq\) 10 mm Hg), the presence of varices, and risk for variceal hemorrhage but is not recommended as a replacement for endoscopy.\(^{64}\) A recent meta-analysis found a pooled PPV and NPV of 88% for the ability of
VCTE to predict the presence of significant portal hypertension. In the largest study to examine this question, Bureau et al prospectively studied 150 consecutive French patients undergoing transjugular liver biopsy and portal pressure measurement, 59% of whom were cirrhotic. Controlling for ALT, aspartate aminotransferase, albumin, international normalized ratio, and platelet count, LSM ≥21 kPa had OR of 120.4 for hepatic venous pressure gradient ≥10 mm Hg. A cutoff of 11.7 kPa had PPV and NPV of 77.4% and 93.1%, respectively, whereas 21.0 kPa had PPV and NPV of 92.5% and 90.7%, respectively. In a retrospective study of 124 Americans with cirrhosis who underwent endoscopy of whom 63 had esophageal varices, our group found that a liver stiffness cutoff of 20 kPa by VCTE yielded PPV and NPV for varices of 80% and 75%, respectively. VCTE has been shown to be as effective as hepatic venous pressure gradient in predicting clinical decompensation in cirrhotic patients. In one study, hepatic venous pressure gradient ≥10 mm Hg and LSM ≥21.1 kPa had 100% NPV for portal hypertensive complications. In a group of 1000 Romanians with cirrhosis, a cutoff of 50.7 kPa had 82.71% PPV and 53.66% NPV for the prediction of esophageal bleeding. Tapper et al discovered that in cirrhotic patients with PBC who were followed with annual VCTE, increases in liver stiffness were powerfully associated with clinical outcomes such as decompensation, liver transplantation, or death. Similarly, in a cohort of 128 Korean patients with active HBV cirrhosis, a cutoff of 19 kPa yielded a hazard ratio of 7.176 for development of clinical decompensation including hepatocellular carcinoma.

VCTE is indeed a robust tool that reproducibly predicts hepatic decompensation. In a group of 667 patients with chronic viral hepatitis who were followed for 861 days, 57 patients died or developed ascites, encephalopathy, variceal bleeding, hepatocellular carcinoma, or listing for transplant. Overall, VCTE had AUROC of 0.87, and a cutoff of 10.5 kPa had NPV of 99.2% for the prediction of these important outcomes. Singh et al recently performed a meta-analysis of all studies examining the predictive power of VCTE for decompensation in chronic liver disease. For every kilopascal over the median LSM obtained, a given patient has an increased relative risk of an important clinical event: 1.07 for hepatic decompensation, 1.11 for hepatocellular carcinoma, and 1.22 for death.

A novel application for VCTE is spleen stiffness measurement, which also aims to predict portal hypertensive events. Spleen stiffness is an investigational technique where the measurements of spleen stiffness are considered reflective of splenic congestion. Further studies to delineate its limitations as well as the range of normal spleen stiffness are needed before clinicians should adopt this technique. First reported in 2011, Stefanescu et al found in their retrospective study that an optimal cutoff of 52.5 kPa rendered AUROC of 0.74 for predicting the presence of varices. The prospective study by Collecchia et al yielded similar results. In a prospective study of 174 Indian patients, among patients with varices, spleen stiffness was significantly higher in patients who had large varices (56 vs 49 kPa) and a history of variceal bleed (58 vs 50.2).

Controlled Attenuation Parameter for Steatosis Staging

A novel technique developed by using VCTE to stage steatosis is termed controlled attenuation parameter (CAP). It is a proprietary algorithm that is based on the ultrasonic attenuation coefficient of VCTE’s shear wave, an estimate of the total ultrasonic attenuation (go-and-return path) at 3.5 MHz. CAP uses the same radiofrequency data as LSM and is only appraised if the acquisition is valid. It is expressed in decibels per meter. In the original report, CAP paired with histology had AUROC of 0.91, 0.95, and 0.89 for steatosis stages 1, 2, and 3, respectively. When later assessed in 615 patients with chronic HCV by the same group, CAP had AUROC of 0.80, 0.86, and 0.88 for stages 1, 2, and 3, respectively. Because steatosis is a reversible marker reflecting the potential for further liver injury, CAP is a promising investigational tool for clinicians to advise patients on future risks and therapeutic strategies. Utilization of CAP in NASH and with the XL probe is eagerly awaited.

Incorporating Transient Elastography Into Practice

Judicious use of VCTE includes selecting appropriate candidates or at least acknowledging confounding factors. At a minimum, this involves knowing the patient’s underlying disease, BMI (obesity), ALT (inflammation), alkaline phosphatase (cholestasis), and whether they are fasting. Thereafter, we recommend that VCTE is performed in conjunction with an assessment of serologic markers of fibrosis such as Fibrotest, Hepascore, FIB4, or APRI. Concordant tests are considered mutually confirmatory, whereas discordant tests can be repeated at a later date and biopsies left only for patients in whom discordant results remain unresolved. (Figure 3).

Perspectives on Vibration-Controlled Transient Elastography From Europe

Since its introduction 10 years ago in France, VCTE has rapidly become very popular not only among patients but also among doctors as a point-of-care technique that could be used in the outpatient clinic. Consequently, VCTE use translated into a significant decrease in the need for liver biopsy for the management
of patients with hepatitis C in routine practice, and this trend has since been observed in most countries where VCTE has been implemented.\textsuperscript{80} VCTE is now widely used in Europe and has been adopted as first-line tool for liver fibrosis evaluation in treatment-naive patients with hepatitis C without comorbidities in France after an independent systematic review by the French health authorities.\textsuperscript{81} Combining VCTE with a biomarker has been shown to increase diagnostic accuracy, particularly for detecting significant fibrosis, a strategy that has been recommended by the latest European Association for the Study of the Liver clinical practice guidelines for managing HCV infection.\textsuperscript{24,82} However, in the largest multicenter independent study to date, VCTE outperformed all other noninvasive tests for the diagnosis of viral cirrhosis. It will likely remain the only end point for fibrosis evaluation in the era of interferon-free regimens.\textsuperscript{83} Because of its high acceptability and its ability to predict hepatic decompensation, VCTE could be a useful tool both to help allocate cirrhotic patients into different categories of risk and to screen for cirrhosis or detect undiagnosed chronic liver disease in the general population.\textsuperscript{64,84} Finally, VCTE remains the noninvasive standard to be beaten for novel challengers such as acoustic radiation force impulse imaging and shear-wave elastography, whose place in clinical practice remains to be defined.\textsuperscript{85}

\section*{Conclusion}

VCTE is coming of age with clinically meaningful applications that are sure to make a substantial impact on the way in which we care for patients with suspected and confirmed liver disease. It is critical that clinicians familiarize themselves with its limitations to maximize VCTE promise and avoid its pitfalls. Further research is needed in American studies to determine the appropriate disease-specific, BMI-controlled liver stiffness cutoffs for advanced liver disease and its complications.

\section*{References}


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Conflicts of interest
These authors disclose the following: Dr Afdhal is a consultant/advisory board member for Echosens, maker of Fibroscan. Dr Castera has served on the speaker’s bureau for Echosens. The remaining author discloses no conflicts.

1. Which of the following parameters is likely to result in a falsely high fibrosis reading during elastography
   a. obesity
   b. active alcohol use
   c. heart failure
   d. portal vein thrombosis
   e. non-fasting state

   **True or False**

2. An operator is considered experienced after performing >100 exams, expert after 500.

3. Abstinence from alcohol for as little as 7 days can lower fibrosis scores determined by elastography

4. ALT levels >80 to 120 may produce false readings suggesting cirrhosis

5. Patients with BMI >30 have a test failure rate of 22% to 25%

6. Elastography results are expressed as pKa (kilopascals) and represent the average of 10 separate measurements.

7. Elastography is equally accurate in assessing fibrosis across all stages (F0 to F4)

8. Elastography does not measure fibrosis, rather it measures liver stiffness, which stratifies risk

9. Elastography is an ideal test to determine if ascites is due to liver fibrosis.

10. Failure to obtain a result during elastography testing correlates with patient BMI >30 and operator inexperience.

11. Bland steatosis may lower fibrosis reading, however, NASH may overestimate fibrosis

12. Elastography can differentiate NAFLD from NASH

13. Elastography can replace endoscopy for variceal screening in cirrhosis

14. Elastography results can predict risk of hepatic decompensation

15. For enhanced accuracy, elastography results should be correlated with other non-invasive markers of fibrosis; if discordant, a liver biopsy should be considered