

(20441)

Medical Benefit		Effective Date: 04/01/18	Next Review Date: 01/20
Preauthorization	No	Review Dates: 01/17, 01/18, 01/19	

Preauthorization is not required.

The following protocol contains medical necessity criteria that apply for this service. The criteria are also applicable to services provided in the local Medicare Advantage operating area for those members, unless separate Medicare Advantage criteria are indicated. If the criteria are not met, reimbursement will be denied and the patient cannot be billed. Please note that payment for covered services is subject to eligibility and the limitations noted in the patient's contract at the time the services are rendered.

Populations	Interventions	Comparators	Outcomes
Individuals: • With chronic liver disease	Interventions of interest are: • FibroSURE serum panels	Comparators of interest are: • Liver biopsy • Noninvasive radiologic methods • Other multianalyte serum assays	Relevant outcomes include: • Test validity • Morbid events • Treatment-related morbidity
Individuals: • With chronic liver disease	Interventions of interest are: • Multianalyte serum assays for liver function assessment other than FibroSURE	Comparators of interest are: • Liver biopsy • Noninvasive radiologic methods • Other multianalyte serum assays	Relevant outcomes include: • Test validity • Morbid events • Treatment-related morbidity
Individuals: • With chronic liver disease	Interventions of interest are: • Transient elastography	Comparators of interest are: • Liver biopsy • Other noninvasive radiologic methods • Multianalyte serum assays	Relevant outcomes include: • Test validity • Morbid events • Treatment-related morbidity
Individuals: • With chronic liver disease	Interventions of interest are: • Noninvasive radiologic methods other than transient elastography for liver fibrosis measurement	Comparators of interest are: • Liver biopsy • Other noninvasive radiologic methods • Multianalyte serum assays	Relevant outcomes include: • Test validity • Morbid events • Treatment-related morbidity

DESCRIPTION

Noninvasive techniques to monitor liver fibrosis are being investigated as alternatives to liver biopsy in patients with chronic liver disease. There are two options for noninvasive monitoring: (1) multianalyte serum assays with algorithmic analysis of either direct or indirect biomarkers; and (2) specialized radiologic methods, including magnetic resonance elastography, transient elastography, acoustic radiation force impulse imaging, and real-time transient elastography.

SUMMARY OF EVIDENCE

Multianalyte Serum Assays

For individuals who have chronic liver disease who receive FibroSURE serum panels, the evidence includes systematic reviews of more than 30 observational studies (more than 5000 patients). Relevant outcomes are test

validity, morbid events, and treatment-related morbidity. FibroSURE has been studied in populations with viral hepatitis, nonalcoholic fatty liver disease, and alcoholic liver disease. There are established cutoffs, although they were not consistently used in validation studies. Given these limitations and the imperfect reference standard, it is difficult to interpret performance characteristics. However, for the purposes of deciding whether a patient has severe fibrosis or cirrhosis, FibroSURE results provide data sufficiently useful to determine therapy. Specifically, FibroSURE has been used as an alternative to biopsy to establish eligibility regarding the presence of fibrosis or cirrhosis in several randomized controlled trials (RCTs) that showed the efficacy of hepatitis C virus treatments, which in turn demonstrated the test can identify patients who would benefit from therapy. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

For individuals who have chronic liver disease who receive multianalyte serum assays for liver function assessment other than FibroSURE, the evidence includes systematic reviews of observational studies. Relevant outcomes are test validity, morbid events, and treatment-related morbidity. Studies have frequently included varying cutoffs, some of which were standardized and others not validated. Given these limitations and the imperfect reference standard, it is difficult to interpret performance characteristics. There is no direct evidence that other multianalyte serum assays improve health outcomes; further, it is not possible to construct a chain of evidence for clinical utility due to the lack of sufficient evidence on clinical validity. The evidence is insufficient to determine the effects of the technology on health outcomes.

Noninvasive Imaging

For individuals who have chronic liver disease who receive transient elastography, the evidence includes many systematic reviews of more than 50 observational studies (more than 10,000 patients). Relevant outcomes are test validity, morbid events, and treatment-related morbidity. Transient elastography (FibroScan) has been studied in populations with viral hepatitis, nonalcoholic fatty liver disease, and alcoholic liver disease. There are varying cutoffs for positivity. Failures of the test are not uncommon, particularly for those with high body mass index, but these failures often went undetected in analyses of the validation studies. Given these limitations and the imperfect reference standard, it can be difficult to interpret performance characteristics. However, for the purposes of deciding whether a patient has severe fibrosis or cirrhosis, the FibroScan results provide data sufficiently useful to determine therapy. In fact, FibroScan has been used as an alternative to biopsy to establish eligibility regarding the presence of fibrosis or cirrhosis in the participants of RCTs. These trials showed the efficacy of hepatitis C virus treatments, which in turn demonstrated that the test can identify patients who would benefit from therapy. The evidence is sufficient to determine that the technology results in a meaningful improvement in the net health outcome.

For individuals who have chronic liver disease who receive noninvasive radiologic methods other than transient elastography for liver fibrosis measurement, the evidence includes systematic reviews of observational studies. Relevant outcomes are test validity, morbid events, and treatment-related morbidity. Other radiologic methods (e.g., magnetic resonance elastography, real-time transient elastography, acoustic radiation force impulse imaging) may have similar performance for detecting significant fibrosis or cirrhosis. Studies have frequently included varying cutoffs not prespecified or validated. Given these limitations and the imperfect reference standard, it is difficult to interpret performance characteristics. There is no direct evidence that other noninvasive radiologic methods improve health outcomes; further, it is not possible to construct a chain of evidence for clinical utility due to the lack of sufficient evidence on clinical validity. The evidence is insufficient to determine the effects of the technology on health outcomes.

POLICY

A single FibroSURE multianalyte assay may be considered **medically necessary** for the evaluation of patients with chronic liver disease.

FibroSURE multianalyte assays are considered **investigational** for monitoring of patients with chronic liver disease.

Other multianalyte assays with algorithmic analyses are considered **investigational** for the evaluation or monitoring of patients with chronic liver disease.

Transient elastography (FibroScan) imaging may be considered **medically necessary** for the evaluation of patients with chronic liver disease.

Transient elastography (FibroScan) imaging is considered **investigational** for monitoring of patients with chronic liver disease.

The use of other noninvasive imaging, including but not limited to magnetic resonance elastography, acoustic radiation force impulse imaging (e.g., Acuson S2000), or real-time tissue elastography, is considered **investigational** for the evaluation or monitoring of patients with chronic liver disease.

POLICY GUIDELINES

Multianalyte assays with algorithmic analyses use the results from multiple assays of various types in an algorithmic analysis to determine and report a numeric score(s) or probability. The results of individual component assays are not reported separately.

This protocol does not address standard imaging with ultrasound (US) or magnetic resonance imaging.

BACKGROUND

BIOPSY FOR CHRONIC LIVER DISEASE

The diagnosis of non-neoplastic liver disease is often made from needle biopsy samples. In addition to establishing a disease etiology, liver biopsy can determine the degree of inflammation present and can stage the degree of fibrosis. The degree of inflammation and fibrosis may be assessed by different scoring schemes. Most of these scoring schemes grade inflammation from 0 (no or minimal inflammation) to 4 (severe) and fibrosis from 0 (no fibrosis) to 4 (cirrhosis). There are several limitations to liver biopsy, including its invasive nature, small tissue sample size, and subjective grading system. Regarding small tissue sample size, liver fibrosis can be patchy and thus missed on a biopsy sample, which includes only 0.002% of the liver tissue. A noninvasive alternative to liver biopsy would be particularly helpful, both to initially assess patients and then to monitoring response to therapy.

HEPATITIS C VIRUS

Infection with hepatitis C virus (HCV) can lead to permanent liver damage. Prior to noninvasive testing, liver biopsy was typically recommended before the initiation of antiviral therapy. Repeat biopsies may be performed to monitor fibrosis progression. Liver biopsies are analyzed according to a histologic scoring system; the most commonly used one for hepatitis C is the Metavir scoring system, which scores the presence and degree of inflammatory activity and fibrosis. The fibrosis is graded from F0 to F4, with a Metavir score of F0 signifying no fibrosis and F4 signifying cirrhosis (which is defined as the presence throughout the liver of fibrous septa that subdivide the liver parenchyma into nodules and represents the final and irreversible form of the disease). The

stage of fibrosis is the most important single predictor of morbidity and mortality in patients with hepatitis C. Biopsies for hepatitis C are also evaluated according to the degree of inflammation present, referred to as the grade or activity level. For example, the Metavir system includes scores for necroinflammatory activity ranging from A0 to A3 (A0 = no activity, A1 = minimal activity, A2 = moderate activity, A3 = severe activity).

HEPATITIS B VIRUS

Most people who become infected with hepatitis B virus recover fully, but a small portion develop chronic hepatitis B virus, which can lead to permanent liver damage. As with HCV, identification of liver fibrosis is needed to determine timing and management of treatment, and liver biopsy is the criterion standard for staging fibrosis. The grading of fibrosis in hepatitis B virus also uses the Metavir system.

ALCOHOLIC LIVER DISEASE

Alcoholic liver disease (ALD) is the leading cause of liver disease in most Western countries. Histologic features of ALD usually include steatosis, alcoholic steatohepatitis, hepatocyte necrosis, Mallory bodies (tangled proteins seen in degenerating hepatocytes), a large polymorphonuclear inflammatory infiltrate, and, with continued alcohol abuse, fibrosis, and possibly cirrhosis. The grading of fibrosis is similar to the scoring system used in hepatitis C. The commonly used Laënnec scoring system uses grades 0 to 4, with 4 being cirrhosis.

NONALCOHOLIC FATTY LIVER DISEASE

Nonalcoholic fatty liver disease (NAFLD) is defined as a condition that pathologically resembles ALD but occurs in patients who are not heavy users of alcohol. Moreover, NAFLD may be associated with a variety of conditions, including obesity, diabetes, and dyslipidemia. The characteristic feature of NAFLD is steatosis. At the benign end of the disease spectrum, there is usually no appreciable inflammation, hepatocyte death, or fibrosis. In contrast, nonalcoholic steatohepatitis (NASH), which shows overlapping histologic features with ALD, is an intermediate form of liver damage, and liver biopsy may show steatosis, Mallory bodies, focal inflammation, and degenerating hepatocytes. NASH can progress to fibrosis and cirrhosis. A variety of histologic scoring systems have been used to evaluate NAFLD. The NAFLD Activity Score system for NASH includes scores for steatosis (0-3), lobular inflammation (0-3), and ballooning (0-2). Cases with scores of 5 or greater are considered NASH, while cases with scores of 3 and 4 are considered borderline (probable or possible) NASH. The grading of fibrosis is similar to the scoring system used in hepatitis C. The commonly used Laënnec scoring system uses grades 0 to 4, with 4 being cirrhosis.

NONINVASIVE ALTERNATIVES TO LIVER BIOPSY

Multianalyte Assays

A variety of noninvasive laboratory tests are being evaluated as alternatives to liver biopsy. Biochemical tests can be broadly categorized into indirect and direct markers of liver fibrosis. Indirect markers include liver function tests such as alanine aminotransferase (ALT), aspartate aminotransferase (AST), the ALT/AST ratio (also referred to as the AAR), platelet count, and prothrombin index. There has been a growing understanding of the underlying pathophysiology of fibrosis, leading to a direct measurement of the factors involved. For example, the central event in the pathophysiology of fibrosis is the activation of the hepatic stellate cell. Normally, stellate cells are quiescent but are activated in the setting of liver injury, producing a variety of extracellular matrix (ECM) proteins. In normal livers, the rate of ECM production equals its degradation, but, with fibrosis, production exceeds degradation. Metalloproteinases are involved in intracellular degradation of ECM, and a profibrogenic state exists when there is either a downregulation of metalloproteinases or an increase in tissue inhibitors of metalloproteinases. Both metalloproteinases and tissue inhibitors of metalloproteinases can be measured in the serum, which directly reflects fibrotic activity. Other direct measures of ECM deposition include hyaluronic acid or α 2-macroglobulin.

While many studies have been done on these individual markers, or on groups of markers in different populations of patients with liver disease, there has been interest in analyzing multiple markers using mathematical algorithms to generate a score that categorizes patients according to the biopsy score. It is proposed that these algorithms can be used as alternatives to liver biopsy in patients with liver disease. The following proprietary, algorithm-based tests are commercially available in the United States.

FibroSURE

HCV FibroSURE

The HCV FibroSURE uses a combination of six serum biochemical indirect markers of liver function plus age and sex in a patented algorithm to generate a measure of fibrosis and necroinflammatory activity in the liver that corresponds to the Metavir scoring system for stage (i.e., fibrosis) and grade (i.e., necroinflammatory activity). The measures are combined using a linear regression equation to produce a score between 0 and 1, with higher values corresponding to more severe disease. The biochemical markers include the readily available measurements of α 2-macroglobulin, haptoglobin, bilirubin, γ -glutamyl transpeptidase, ALT, and apolipoprotein AI. Developed in France, the test has been clinically available in Europe under the name FibroTest since 2003; it is exclusively offered by LabCorp in the United States as HCV FibroSURE.

ASH FibroSURE

ASH FibroSURE (ASH Test) uses a combination of 10 serum biochemical markers of liver function together with age, sex, height, and weight in a proprietary algorithm; the test is proposed to provide surrogate markers for liver fibrosis, hepatic steatosis, and ASH. The biochemical markers include α 2-macroglobulin, haptoglobin, apolipoprotein AI, bilirubin, γ -glutamyl transpeptidase, ALT, AST, total cholesterol, triglycerides, and fasting glucose. The test has been available in Europe under the name AshTest™ (BioPredictive); the test is exclusively offered by LabCorp in the United States as ASH FibroSURE.

NASH FibroSURE

NASH FibroSURE (NASH Test) uses a proprietary algorithm of the same 10 biochemical markers of liver function in combination with age, sex, height, and weight and is proposed to provide surrogate markers for liver fibrosis, hepatic steatosis, and NASH. The biochemical markers include α 2-macroglobulin, haptoglobin, apolipoprotein AI, bilirubin, γ -glutamyl transpeptidase, ALT, AST, total cholesterol, triglycerides, and fasting glucose. The test has been available in Europe under the name NashTest™ (BioPredictive); the test is exclusively offered by LabCorp in the United States as NASH FibroSURE.

FIBROSpect II

FIBROSpect II uses a combination of three markers that directly measure fibrogenesis of the liver, analyzed with a patented algorithm. The markers include hyaluronic acid, tissue inhibitor of metalloproteinase 1, and α 2-macroglobulin. FIBROSpect II is offered exclusively by Prometheus Laboratories. The measures are combined using a logistic regression algorithm to generate a FIBROSpect II index score, ranging from 1 to 100 (or sometimes reported between 0 and 1), with higher scores indicating more severe disease.

NONINVASIVE IMAGING TECHNOLOGIES

Noninvasive imaging technologies to detect liver fibrosis or cirrhosis among patients with chronic liver disease are being evaluated as alternatives to liver biopsy. The noninvasive imaging technologies include transient elastography (e.g., FibroScan), magnetic resonance elastography, acoustic radiation force impulse (ARFI) imaging (e.g., Acuson S2000), and real-time tissue elastography (e.g., HI VISION Preirus). Noninvasive imaging tests have been used in combination with multianalyte serum tests such as FibroTest or FibroSURE with FibroScan.

Transient Elastography

Transient elastography (FibroScan) uses a mechanical vibrator to produce mild amplitude and low frequency (50 Hz) waves, inducing an elastic shear wave that propagates throughout the liver. Ultrasound tracks the wave, measuring its speed in kilopascals, which correlates with liver stiffness. Increases in liver fibrosis also increase liver stiffness and resistance of liver blood flow. Transient elastography does not perform as well in patients with ascites, higher body mass index, or narrow intercostal margins. Although FibroScan may be used to measure fibrosis (unlike liver biopsy), it does not provide information on necroinflammatory activity and steatosis, nor is it accurate during acute hepatitis or hepatitis exacerbations.

ARFI Imaging

ARFI imaging uses an ultrasound probe to produce an acoustic “push” pulse, which generates shear waves that propagate in tissue to assess liver stiffness. ARFI elastography evaluates the wave propagation speed (measured in meters per second) to assess liver stiffness. The faster the shear wave speed, the harder the object. ARFI technologies include Virtual Touch Quantification and Siemens Acuson S2000 system. ARFI elastography can be performed at the same time as a liver sonographic evaluation, even in patients with a significant amount of ascites.

Magnetic Resonance Elastography

Magnetic resonance elastography uses a driver to generate 60-Hz mechanical waves on the patient’s chest wall. The magnetic resonance equipment creates elastograms by processing the acquired images of propagating shear waves in the liver using an inversion algorithm. These elastograms represent the shear stiffness as a pixel value in kilopascals. Magnetic resonance elastography has several advantages over ultrasound elastography, including: (1) the ability to analyze larger liver volumes; (2) the ability to analyze liver volumes of obese patients or patients with ascites; and (3) the ability to precisely analyze viscoelasticity using a three-dimensional displacement vector.

Real-Time Tissue Elastography

Real-time tissue elastography is a type of strain elastography that uses a combined autocorrelation method to measure tissue strain caused by manual compression or a person’s heartbeat. The relative tissue strain is displayed on conventional color B mode ultrasound images in real time. Hitachi manufactures real-time tissue elastography devices, including the HI VISION Preirus. The challenge is to identify a region of interest while avoiding areas likely to introduce artifacts, such as large blood vessels, the area near the ribs, and the surface of the liver. Areas of low strain increase as fibrosis progresses and strain distribution becomes more complex. Various subjective and quantitative methods have been developed to evaluate the results. Real-time tissue elastography can be performed in patients with ascites or inflammation. This technology does not perform as well in severely obese individuals.

REGULATORY STATUS

In 2008 Acuson S2000™ Virtual Touch (Siemens AG), which provides ARFI imaging, was cleared for marketing by the U.S. Food and Drug Administration (FDA) through the 510(k) process (K072786)(K123622).

In 2009, AIXPLORER® Ultrasound System (SuperSonic Imagine), which provides shear wave elastography, was cleared for marketing by the FDA through the 510(k) process (K091970).

In 2010, Hitachi HI VISION™ Preirus™ Diagnostic Ultrasound Scantier (Hitachi Medical Systems America), which provides real-time tissue elastography, was cleared for marketing by the FDA through the 510(k) process (K093466).

In 2013, FibroScan® (EchoSens), which uses transient elastography, was cleared for marketing by the FDA through the 510(k) process (K123806).

In February 2017, ElastQ Imaging shear wave elastography (Royal Phillips) was cleared for marketing by the FDA through the 510(k) process (K163120).

FDA product code: IYO.

Services that are the subject of a clinical trial do not meet our Technology Assessment Protocol criteria and are considered investigational. *For explanation of experimental and investigational, please refer to the Technology Assessment Protocol.*

It is expected that only appropriate and medically necessary services will be rendered. We reserve the right to conduct prepayment and postpayment reviews to assess the medical appropriateness of the above-referenced procedures. **Some of this protocol may not pertain to the patients you provide care to, as it may relate to products that are not available in your geographic area.**

REFERENCES

We are not responsible for the continuing viability of web site addresses that may be listed in any references below.

1. Regev A, Berho M, Jeffers LJ, et al. Sampling error and intraobserver variation in liver biopsy in patients with chronic HCV infection. *Am J Gastroenterol.* Oct 2002;97(10):2614-2618. PMID 12385448
2. Rockey DC, Caldwell SH, Goodman ZD, et al. Liver biopsy. *Hepatology.* Mar 2009;49(3):1017-1044. PMID 19243014
3. Mehta SH, Lau B, Afdhal NH, et al. Exceeding the limits of liver histology markers. *J Hepatol.* Jan 2009;50(1):36-41. PMID 19012989
4. Trikalinos TA, Balion CM. Chapter 9: options for summarizing medical test performance in the absence of a “gold standard”. *J Gen Intern Med.* Jun 2012;27(Suppl 1):S67-75. PMID 22648677
5. Crossan C, Tsochatzis EA, Longworth L, et al. Cost-effectiveness of non-invasive methods for assessment and monitoring of liver fibrosis and cirrhosis in patients with chronic liver disease: systematic review and economic evaluation. *Health Technol Assess.* Jan 2015;19(9):1-409, v-vi. PMID 25633908
6. Houot M, Ngo Y, Munteanu M, et al. Systematic review with meta-analysis: direct comparisons of biomarkers for the diagnosis of fibrosis in chronic hepatitis C and B. *Aliment Pharmacol Ther.* Jan 2016;43(1):16-29. PMID 26516104
7. Imbert-Bismut F, Ratziu V, Pieroni L, et al. Biochemical markers of liver fibrosis in patients with hepatitis C virus infection: a prospective study. *Lancet.* Apr 7 2001;357(9262):1069-1075. PMID 11297957
8. Poynard T, McHutchison J, Manns M, et al. Biochemical surrogate markers of liver fibrosis and activity in a randomized trial of peginterferon alfa-2b and ribavirin. *Hepatology.* Aug 2003;38(2):481-492. PMID 12883493
9. Poynard T, Munteanu M, Imbert-Bismut F, et al. Prospective analysis of discordant results between biochemical markers and biopsy in patients with chronic hepatitis C. *Clin Chem.* Aug 2004;50(8):1344-1355. PMID 15192028
10. Afdhal NH, Nunes D. Evaluation of liver fibrosis: a concise review. *Am J Gastroenterol.* Jun 2004;99(6):1160-1174. PMID 15180741

11. Lichtiginghagen R, Bahr MJ. Noninvasive diagnosis of fibrosis in chronic liver disease. *Expert Rev Mol Diagn.* Sep 2004;4(5):715-726. PMID 15347264
12. Rossi E, Adams L, Prins A, et al. Validation of the FibroTest biochemical markers score in assessing liver fibrosis in hepatitis C patients. *Clin Chem.* Mar 2003;49(3):450-454. PMID 12600957
13. Poynard T, de Ledinghen V, Zarski JP, et al. Relative performances of FibroTest, Fibroscan, and biopsy for the assessment of the stage of liver fibrosis in patients with chronic hepatitis C: a step toward the truth in the absence of a gold standard. *J Hepatol.* Mar 2012;56(3):541-548. PMID 21889468
14. Afdhal N, Reddy KR, Nelson DR, et al. Ledipasvir and sofosbuvir for previously treated HCV genotype 1 infection. *N Engl J Med.* Apr 17 2014;370(16):1483-1493. PMID 24725238
15. Afdhal N, Zeuzem S, Kwo P, et al. Ledipasvir and sofosbuvir for untreated HCV genotype 1 infection. *N Engl J Med.* May 15 2014;370(20):1889-1898. PMID 24725239
16. Curry MP, O'Leary JG, Bzowej N, et al. Sofosbuvir and velpatasvir for HCV in patients with decompensated cirrhosis. *N Engl J Med.* Dec 31 2015;373(27):2618-2628. PMID 26569658
17. Foster GR, Afdhal N, Roberts SK, et al. Sofosbuvir and velpatasvir for HCV genotype 2 and 3 infection. *N Engl J Med.* Dec 31 2015;373(27):2608-2617. PMID 26575258
18. Kowdley KV, Gordon SC, Reddy KR, et al. Ledipasvir and sofosbuvir for 8 or 12 weeks for chronic HCV without cirrhosis. *N Engl J Med.* May 15 2014;370(20):1879-1888. PMID 24720702
19. Zeuzem S, Dusheiko GM, Salupere R, et al. Sofosbuvir and ribavirin in HCV genotypes 2 and 3. *N Engl J Med.* May 22 2014;370(21):1993-2001. PMID 24795201
20. Naveau S, Raynard B, Ratzu V, et al. Biomarkers for the prediction of liver fibrosis in patients with chronic alcoholic liver disease. *Clin Gastroenterol Hepatol.* Feb 2005;3(2):167-174. PMID 15704051
21. Ratzu V, Massard J, Charlotte F, et al. Diagnostic value of biochemical markers (FibroTest-FibroSURE) for the prediction of liver fibrosis in patients with non-alcoholic fatty liver disease. *BMC Gastroenterol.* 2006;6:6. PMID 16503961
22. Thabut D, Naveau S, Charlotte F, et al. The diagnostic value of biomarkers (AshTest) for the prediction of alcoholic steato-hepatitis in patients with chronic alcoholic liver disease. *J Hepatol.* Jun 2006;44(6):1175-1185. PMID 16580087
23. Poynard T, Ratzu V, Charlotte F, et al. Diagnostic value of biochemical markers (NashTest) for the prediction of non alcoholic steato hepatitis in patients with non-alcoholic fatty liver disease. *BMC Gastroenterol.* Nov 10 2006;6:34. PMID 17096854
24. Lassailly G, Caiazzo R, Hollebecque A, et al. Validation of noninvasive biomarkers (FibroTest, SteatoTest, and NashTest) for prediction of liver injury in patients with morbid obesity. *Eur J Gastroenterol Hepatol.* Jun 2011;23(6):499-506. PMID 21499110
25. Mohamadnejad M, Montazeri G, Fazlollahi A, et al. Noninvasive markers of liver fibrosis and inflammation in chronic hepatitis B-virus related liver disease. *Am J Gastroenterol.* Nov 2006;101(11):2537-2545. PMID 17029616
26. Zeng MD, Lu LG, Mao YM, et al. Prediction of significant fibrosis in HBeAg-positive patients with chronic hepatitis B by a noninvasive model. *Hepatology.* Dec 2005;42(6):1437-1445. PMID 16317674
27. Park MS, Kim BK, Cheong JY, et al. Discordance between liver biopsy and FibroTest in assessing liver fibrosis in chronic hepatitis B. *PLoS One.* Feb 2013;8(2):e55759. PMID 23405210
28. Salkic NN, Jovanovic P, Hauser G, et al. FibroTest/Fibrosure for significant liver fibrosis and cirrhosis in chronic hepatitis B: a meta-analysis. *Am J Gastroenterol.* Jun 2014;109(6):796-809. PMID 24535095
29. Xu XY, Kong H, Song RX, et al. The effectiveness of noninvasive biomarkers to predict hepatitis B-related significant fibrosis and cirrhosis: a systematic review and meta-analysis of diagnostic test accuracy. *PLoS One.* Jun 25 2014;9(6):e100182. PMID 24964038
30. Wai CT, Cheng CL, Wee A, et al. Non-invasive models for predicting histology in patients with chronic hepatitis B. *Liver Int.* Aug 2006;26(6):666-672. PMID 16842322

31. Patel K, Gordon SC, Jacobson I, et al. Evaluation of a panel of non-invasive serum markers to differentiate mild from moderate-to-advanced liver fibrosis in chronic hepatitis C patients. *J Hepatol*. Dec 2004;41(6):935-942. PMID 15582126
32. Christensen C, Bruden D, Livingston S, et al. Diagnostic accuracy of a fibrosis serum panel (FIBROSpect II) compared with Knodell and Ishak liver biopsy scores in chronic hepatitis C patients. *J Viral Hepat*. Oct 2006;13(10):652-658. PMID 16970596
33. Mehta P, Ploutz-Snyder R, Nandi J, et al. Diagnostic accuracy of serum hyaluronic acid, FIBROSpect II, and YKL-40 for discriminating fibrosis stages in chronic hepatitis C. *Am J Gastroenterol*. Apr 2008;103(4):928-936. PMID 18371145
34. Patel K, Nelson DR, Rockey DC, et al. Correlation of FIBROSpect II with histologic and morphometric evaluation of liver fibrosis in chronic hepatitis C. *Clin Gastroenterol Hepatol*. Feb 2008;6(2):242-247. PMID 18187364
35. Snyder N, Nguyen A, Gajula L, et al. The APRI may be enhanced by the use of the FIBROSpect II in the estimation of fibrosis in chronic hepatitis C. *Clin Chim Acta*. Jun 2007;381(2):119-123. PMID 17442291
36. Wai CT, Greenson JK, Fontana RJ, et al. A simple noninvasive index can predict both significant fibrosis and cirrhosis in patients with chronic hepatitis C. *Hepatology*. Aug 2003;38(2):518-526. PMID 12883497
37. Giannini EG, Zaman A, Ceppa P, et al. A simple approach to noninvasively identifying significant fibrosis in chronic hepatitis C patients in clinical practice. *J Clin Gastroenterol*. Jul 2006;40(6):521-527. PMID 16825935
38. Bourliere M, Penaranda G, Renou C, et al. Validation and comparison of indexes for fibrosis and cirrhosis prediction in chronic hepatitis C patients: proposal for a pragmatic approach classification without liver biopsies. *J Viral Hepat*. Oct 2006;13(10):659-670. PMID 16970597
39. Zarski JP, Sturm N, Guechot J, et al. Comparison of nine blood tests and transient elastography for liver fibrosis in chronic hepatitis C: the ANRS HCEP-23 study. *J Hepatol*. Jan 2012;56(1):55-62. PMID 21781944
40. Sebastiani G, Halfon P, Castera L, et al. SAFE biopsy: a validated method for large-scale staging of liver fibrosis in chronic hepatitis C. *Hepatology*. Jun 2009;49(6):1821-1827. PMID 19291784
41. Boursier J, de Ledinghen V, Zarski JP, et al. Comparison of eight diagnostic algorithms for liver fibrosis in hepatitis C: new algorithms are more precise and entirely noninvasive. *Hepatology*. Jan 2012;55(1):58-67. PMID 21898504
42. Rosenberg WM, Voelker M, Thiel R, et al. Serum markers detect the presence of liver fibrosis: a cohort study. *Gastroenterology*. Dec 2004;127(6):1704-1713. PMID 15578508
43. Brener S. Transient elastography for assessment of liver fibrosis and steatosis: an evidence-based analysis. *Ont Health Technol Assess Ser*. Dec 2015;15(18):1-45. PMID 26664664
44. Bota S, Herkner H, Sporea I, et al. Meta-analysis: ARFI elastography versus transient elastography for the evaluation of liver fibrosis. *Liver Int*. Sep 2013;33(8):1138-1147. PMID 23859217
45. Chon YE, Choi EH, Song KJ, et al. Performance of transient elastography for the staging of liver fibrosis in patients with chronic hepatitis B: a meta-analysis. *PLoS One*. Oct 2012;7(9):e44930. PMID 23049764
46. Friedrich-Rust M, Nierhoff J, Lupsor M, et al. Performance of Acoustic Radiation Force Impulse imaging for the staging of liver fibrosis: a pooled meta-analysis. *J Viral Hepat*. Feb 2012;19(2):e212-219. PMID 22239521
47. Friedrich-Rust M, Ong MF, Martens S, et al. Performance of transient elastography for the staging of liver fibrosis: a meta-analysis. *Gastroenterology*. Apr 2008;134(4):960-974. PMID 18395077
48. Kwok R, Tse YK, Wong GL, et al. Systematic review with meta-analysis: non-invasive assessment of nonalcoholic fatty liver disease--the role of transient elastography and plasma cytokeratin-18 fragments. *Aliment Pharmacol Ther*. Feb 2014;39(3):254-269. PMID 24308774
49. Poynard T, Morra R, Ingiliz P, et al. Assessment of liver fibrosis: noninvasive means. *Saudi J Gastroenterol*. Oct 2008;14(4):163-173. PMID 19568532
50. Poynard T, Ngo Y, Munteanu M, et al. Noninvasive markers of hepatic fibrosis in chronic hepatitis B. *Curr Hepat Rep*. Jun 2011;10(2):87-97. PMID 21654911

51. Shaheen AA, Wan AF, Myers RP. FibroTest and FibroScan for the prediction of hepatitis C-related fibrosis: a systematic review of diagnostic test accuracy. *Am J Gastroenterol*. Nov 2007;102(11):2589-2600. PMID 17850410
52. Shi KQ, Tang JZ, Zhu XL, et al. Controlled attenuation parameter for the detection of steatosis severity in chronic liver disease: a meta-analysis of diagnostic accuracy. *J Gastroenterol Hepatol*. Jun 2014;29(6):1149-1158. PMID 24476011
53. Steadman R, Myers RP, Leggett L, et al. A health technology assessment of transient elastography in adult liver disease. *Can J Gastroenterol*. Mar 2013;27(3):149-158. PMID 23516679
54. Stebbing J, Farouk L, Panos G, et al. A meta-analysis of transient elastography for the detection of hepatic fibrosis. *J Clin Gastroenterol*. Mar 2010;44(3):214-219. PMID 19745758
55. Talwalkar JA, Kurtz DM, Schoenleber SJ, et al. Ultrasound-based transient elastography for the detection of hepatic fibrosis: systematic review and meta-analysis. *Clin Gastroenterol Hepatol*. Oct 2007;5(10):1214-1220. PMID 17916549
56. Tsochatzis EA, Gurusamy KS, Ntaoula S, et al. Elastography for the diagnosis of severity of fibrosis in chronic liver disease: a meta-analysis of diagnostic accuracy. *J Hepatol*. Apr 2011;54(4):650-659. PMID 21146892
57. Tsochatzis EA, Crossan C, Longworth L, et al. Cost-effectiveness of noninvasive liver fibrosis tests for treatment decisions in patients with chronic hepatitis C. *Hepatology*. Sep 2014;60(3):832-843. PMID 25043847
58. Geng XX, Huang RG, Lin JM, et al. Transient elastography in clinical detection of liver cirrhosis: A systematic review and meta-analysis. *Saudi J Gastroenterol*. Jul-Aug 2016;22(4):294-303. PMID 27488324
59. Jiang W, Huang S, Teng H, et al. Diagnostic accuracy of point shear wave elastography and transient elastography for staging hepatic fibrosis in patients with non-alcoholic fatty liver disease: a meta-analysis. *BMJ Open*. Aug 23 2018;8(8):e021787. PMID 30139901
60. Li Y, Huang YS, Wang ZZ, et al. Systematic review with meta-analysis: the diagnostic accuracy of transient elastography for the staging of liver fibrosis in patients with chronic hepatitis B. *Aliment Pharmacol Ther*. Feb 2016;43(4):458-469. PMID 26669632
61. Njei B, McCarty TR, Luk J, et al. Use of transient elastography in patients with HIV-HCV coinfection: A systematic review and meta-analysis. *J Gastroenterol Hepatol*. Oct 2016;31(10):1684-1693. PMID 26952020
62. Pavlov CS, Casazza G, Nikolova D, et al. Transient elastography for diagnosis of stages of hepatic fibrosis and cirrhosis in people with alcoholic liver disease. *Cochrane Database Syst Rev*. Jan 22 2015;1:CD010542. PMID 25612182
63. Xu X, Su Y, Song R, et al. Performance of transient elastography assessing fibrosis of single hepatitis B virus infection: a systematic review and meta-analysis of a diagnostic test. *Hepatol Int*. Oct 2015;9(4):558-566. PMID 26187292
64. Guo Y, Parthasarathy S, Goyal P, et al. Magnetic resonance elastography and acoustic radiation force impulse for staging hepatic fibrosis: a meta-analysis. *Abdom Imaging*. Apr 2015;40(4):818-834. PMID 24711064
65. Hu X, Qiu L, Liu D, et al. Acoustic Radiation Force Impulse (ARFI) Elastography for noninvasive evaluation of hepatic fibrosis in chronic hepatitis B and C patients: a systematic review and meta-analysis. *Med Ultrason*. Jan 31 2017;19(1):23-31. PMID 28180193
66. Liu H, Fu J, Hong R, et al. Acoustic radiation force impulse elastography for the non-invasive evaluation of hepatic fibrosis in non-alcoholic fatty liver disease patients: a systematic review & meta-analysis. *PLoS One*. Jul 2015;10(7):e0127782. PMID 26131717
67. Nierhoff J, Chavez Ortiz AA, Herrmann E, et al. The efficiency of acoustic radiation force impulse imaging for the staging of liver fibrosis: a meta-analysis. *Eur Radiol*. Nov 2013;23(11):3040-3053. PMID 23801420
68. Singh S, Venkatesh SK, Wang Z, et al. Diagnostic performance of magnetic resonance elastography in staging liver fibrosis: a systematic review and meta-analysis of individual participant data. *Clin Gastroenterol Hepatol*. Mar 2015;13(3):440-451 e446. PMID 25305349

69. Singh S, Venkatesh SK, Loomba R, et al. Magnetic resonance elastography for staging liver fibrosis in non-alcoholic fatty liver disease: a diagnostic accuracy systematic review and individual participant data pooled analysis. *Eur Radiol*. May 2016;26(5):1431-1440. PMID 26314479
70. Kobayashi K, Nakao H, Nishiyama T, et al. Diagnostic accuracy of real-time tissue elastography for the staging of liver fibrosis: a meta-analysis. *Eur Radiol*. Jan 2015;25(1):230-238. PMID 25149296
71. Hong H, Li J, Jin Y, et al. Performance of real-time elastography for the staging of hepatic fibrosis: a meta-analysis. *PLoS One*. Dec 2014;9(12):e115702. PMID 25541695
72. Chalasani N. The diagnosis and management of nonalcoholic fatty liver disease: Practice Guidance From the American Association for the Study of Liver Diseases. *Hepatology*. Jan 2018;67(1):328-357. PMID 28714183
73. National Institute for Health and Care Excellence (NICE). Non-alcoholic fatty liver disease (NAFLD): assessment and management [NG49]. 2016; <https://www.nice.org.uk/guidance/ng49>. Accessed October 30, 2018.
74. Singh S, Muir AJ, Dieterich DT, et al. American Gastroenterological Association Institute Technical Review on the role of elastography in chronic liver diseases. *Gastroenterology*. May 2017;152(6):1544-1577. PMID 28442120
75. National Institute for Health and Care Excellence (NICE). Hepatitis B (chronic): diagnosis and management [CG165]. 2013; <https://www.nice.org.uk/guidance/cg165>. Accessed October 30, 2018.
76. American Association for the Study of Liver Diseases, Infectious Diseases Society of America. HCV Guidance: Recommendations for Testing, Managing, and Treating Hepatitis C. 2018; https://www.hcvguidelines.org/sites/default/files/full-guidance-pdf/HCVGuidance_May_24_2018b.pdf. Accessed October 30, 2018.
77. Horowitz JM, Kamel IR, Arif-Tiwari H, et al. ACR Appropriateness Criteria(R) Chronic Liver Disease. *J Am Coll Radiol*. May 2017;14(5s):S103-s117. PMID 28473066
78. European Association for Study of Liver, Asociacion Latinoamericana para el Estudio del Hgado. EASL-ALEH Clinical Practice Guidelines: Non-invasive tests for evaluation of liver disease severity and prognosis. *J Hepatol*. Jul 2015;63(1):237-264. PMID 25911335