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Correlation of Liver Fibroscan Results with Liver Elastographyand Liver Enzymes in Patients with Fatty Liver

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Abstract

Background: Accurate diagnosis of fatty liver is crucial for prognosis and treatment planning.

Objectives: This study aimed to correlate liver fibroscan results with shear wave elastography and liver enzyme levels in fatty liver patients.

Methods: In a cross-sectional study, 80 fatty liver patients from Shahid Motahari Clinic in Shiraz was examined over six months. Diagnoses were made using fibroscan (Echosense 500) and CAP scores, while the Hepatorenal Index was measured with shear wave elastography (Sypersonic, Aixplorer elit). Previous sonography reports were collected for correlation.

Results: Patients' average age was 50.91 years so that 45% were men, and 55% were women. About 78.8% diagnosed with fatty liver by ultrasound were also diagnosed by elastography (true positive). A weak, non-significant positive correlation was observed between the Ratio and CAP score ($r = 0.18$, $P = 0.87$). ALT predicted fatty liver by elastography with 83.6% sensitivity and 64.7% specificity. Few studies in Iran have explored elastography and fibroscan correlation in fatty liver.

Conclusions: Shear wave elastography is a valuable non-invasive technique for predicting fatty liver.

Keywords: Fatty Liver, Shear Wave Elastography, Fibroscan, Liver Enzymes

1. Background

Fatty liver is a significant cause of death related to liver diseases. Consumption of alcohol, malnutrition, fatty foods, excess weight, inactivity, high blood pressure, pregnancy, and using drugs like tetracycline and aspirin are the causes of this disease (1). Three out of ten Iranians suffer from fatty liver, with increasing prevalence in children (2). Obesity is closely linked to fatty liver. Insulin resistance, a precursor to diabetes and the basis of metabolic syndrome can harm liver cells even before diabetes onset. Metabolic syndrome, comprising high blood pressure, high blood fat, obesity, and diabetes, increases fatty liver severity (3). Most patients are asymptomatic, with the disease often detected by elevated liver enzymes in blood tests or during abdominal ultrasounds. Rarely, some may experience fatigue or vague upper right abdominal pain (4).

Most patients with fatty liver disease are diagnosed with simple liver tests in blood specimens or using imaging techniques like liver sonography (5). Increased liver enzymes, found in 50% of fatty liver cases, do not directly correlate with disease severity but reach 80% in advanced stages (6). Sonography, the most common diagnostic method, is non-invasive, affordable, and accessible. CT scans, which are more expensive and use X-rays, are less sensitive than sonography for identifying fatty liver (7). Liver biopsy is the most accurate method for evaluating liver damage in patients with suspicious history or clinical examination (8).

Vibration-controlled transient elastography offers a reliable and cost-effective alternative to liver biopsy for assessing liver stiffness, utilizing a 50Hz elastic wave detector and transducer for measurement (9). In chronic hepatitis C patients, serum levels are inversely correlated with liver fibrosis progression (10). Similarly, low serum zinc levels were significantly associated with

advanced liver fibrosis in another study of chronic hepatitis C cases (11).

Accurate fatty liver and hepatic inflammation diagnosis are vital for prognosis and treatment planning (12). Early detection enhances treatment response. Ultrasound is valuable for diagnosis and monitoring, often paired with s (13).

2. Objectives

This study aims to correlate liver fibroscan results with elastography and liver enzymes in fatty liver patients, recognizing the significance of timely diagnosis.

3. Methods

This descriptive and analytical cross-sectional study included patients diagnosed with fatty liver by Fibroscan and sonography, who attended the Fatty Liver Clinic of Shahid Motahari, Shiraz University of Medical Sciences, in the first half of 2023. The inclusion criteria were fatty liver diagnosed by a gastroenterologist, and patients with liver mass or malignancy were excluded.

Data were collected using a prepared checklist, including demographic information, like age, findings from the Fibroscan, liver elastography findings, and laboratory findings, such as liver enzymes.

The data collection permission was secured from the Research Vice-Chancellor of Shiraz University of Medical Sciences after obtaining approval for the research project. Eligible patients at the Fatty Liver Clinic of Shahid Motahari in Shiraz underwent an examination by a gastroenterologist. Liver enzyme tests, Fibroscan, and liver elastography were conducted, and the results were recorded on a checklist. AST was included in the liver enzyme tests, and the CAP score was utilized to determine steatosis. A radiology assistant performed liver elastography under the supervision of a radiologist, with the Hepatorenal Index measured to determine steatosis.

3.1. Statistical Analysis

The data were analyzed using SPSS software version 24, with descriptive statistics presented in Tables and graphs showing mean and standard deviation. Chi-square and independent t-tests were used for analysis. Spearman's correlation coefficient was employed to assess the correlation between elastography, fibroscan findings, and liver enzymes. ROC curve analysis was performed to determine the sensitivity and specificity of fibroscan, elastography, and liver enzymes in diagnosing fatty liver. The significance level was set at 0.05.

4. Results

This study aimed to correlate liver elastography results with fibroscan and liver enzymes in fatty liver patients. Based on ultrasound results, 80 patients diagnosed with fatty liver were evaluated. The mean age of the patients was 50.91 ± 9.48 years, with the oldest being 66 and the youngest 29. Among the 80 patients studied, 36 (45%) were men and 44 (55%) were women.

4.1. Ultrasound Findings

25% had grade 1, 47.5% had grade 2, and 27.5% had grade Three fatty liver. Of those diagnosed with fatty liver by ultrasound, 78.8% were confirmed by elastography (true positive), while 21.3% were falsely diagnosed as healthy.

The average age of fatty liver patients was lower than that of healthy individuals but not significantly different. Female frequency was higher but not significant. Average CAP score was higher in fatty liver patients but not considerably. The steatosis (a term healthcare providers use to describe fat buildup in an organ (usually your liver)) percentage was lower in fatty liver patients. Average AST and ALT enzymes were significantly higher in fatty liver patients than healthy individuals (Table 1).

A positive but weak correlation between Ratio and CAP score was found (Figure 1), which was insignificant ($r = 0.018$, $P = 0.87$). ROC curve analysis showed that the cutoff point values of 320 for the CAP score, with AUC = 0.500, sensitivity 66.7%, and specificity 70.6%, which were not statistically significant ($P = 0.99$). Thus, the The CAP score from a fibroscan cannot predict fatty liver when diagnosed by elastography.

A positive but weak correlation between Ratio and AST was not significant ($r = 0.024$, $P = 0.83$). ROC curve analysis (Figure 2) for AST showed nonsignificant results ($P = 0.85$), indicating AST cannot predict fatty liver.

There was a positive but weak correlation between Ratio and ALT ($r = 0.173$, $P = 0.13$). A ROC curve analysis for ALT revealed significant results ($P = 0.043$), indicating that ALT is 82.6% sensitive and 65% specific for predicting fatty liver.

5. Discussion

In non-alcoholic patients, hepatic steatosis poses a significant public health risk. Non-alcoholic fatty liver disease (NAFLD) accounts for 75% of the chronic liver disease burden in the Western world, leading to severe

Table 1. Distribution of Study Variables Between Patients Diagnosed with Fatty Liver and Healthyin Elastography [a]

Variables	HRI < 1.2 [b]	HRI > 1.2	P-Value
Age	52.83 ± 9.17	50.44 ± 9.58	0.44
Gender			0.72
Male	7 (41.2)	29 (46.0)	
Female	10 (58.8)	34 (54.0)	
CAP score	340 ± 37.66	340.04 ± 40.21	0.99
Steatosis percent	80.76 ± 14.25	81.20 ± 14.84	0.91
Steatosis stage			0.94
Stage II	2 (11.8)	7 (11.1)	
Stage III	15 (88.2)	56 (88.9)	
AST	26.47 ± 3.62	32.08 ± 21.24	0.045
ALT	29.05 ± 10.43	47.88 ± 39.43	0.001

[a] Values are expressed as mean ± SD or No. (%).

[b] Hepatorenal index.

complications and often requiring liver transplantation (14, 15). Diagnosis typically involves routine ultrasound and liver enzyme tests, with liver biopsy as the gold standard. Non-invasive imaging methods like ultrasound, CT, and MRI are effective but may not distinguish between types of liver fat (16-19). Transient elastography, particularly the CAP parameter, offers a quantitative assessment of liver fat but is operator-dependent (20). Given steatosis's significance in NAFLD, accurate evaluation is crucial for treatment. Ultrasound remains the most cost-effective and common method for diagnosing liver steatosis, characterized by specific sonographic findings (21).

Ultrasound lacks objectivity in measuring liver steatosis (17). Elastography, including point shear wave elastography (pSWE) and two-dimensional shear wave elastography (2D-SWE) offers a new dimension to liver assessment (22, 23). Unlike transient elastography (TE), 2D-SWE is unaffected by obesity and ascites (24). However, the exact role of elastography in diagnosing fatty liver disease is still unclear.

The present study aimed to correlate liver elastography results with fibroscan and liver enzymes in fatty liver patients.

Initial research on the Hepatorenal Index (HRI) has indicated strong diagnostic precision (17, 25, 26). Stahlschmidt et al. (27) confirmed its effectiveness in identifying various levels of steatosis, echoing the present results. Previous studies have also endorsed HRI's utility in diagnosing fatty liver disease without advanced fibrosis (28). Johnson et al. (15) highlighted its 72% accuracy in classifying hepatic steatosis, underscoring its value in monitoring disease evolution and treatment efficacy. However, Kjaergaard et al. (29) and Moret et al. (30) reported moderate diagnostic accuracy in alcoholic and non-alcoholic fatty liver disease cases. Moret et al. found similar results in detecting any degree of steatosis (≥ S1) using HRI through B-mode ultrasound (30). Yet, the present study surpassed these findings in accuracy (31, 32).

The variance between the present study and these previous ones could be attributed to image quality discrepancies. A prior study assessed high-quality and low-quality images, unlike ours, which only evaluated high-quality images. Kjaergaard et al. (29) noted that diagnostic accuracy improved from moderate to good when only high-quality images were considered, although this enhancement was not statistically significant. This underscores the significance of utilizing high-quality measurements.

Marshall et al. discovered that the Hepatorenal Index (HRI) effectively excludes hepatic steatosis, reducing unnecessary biopsies (33). Similarly, Shiralkar et al. showed that HRI, determined via DICOM images in PACS without extra software, detects steatosis above 5%, making it cost-effective for liver evaluation (34). Quantifying steatosis with HRI aids treatment assessment and monitors therapeutic responses, especially in treated patients (15). However, HRI cannot grade steatosis in advanced chronic liver disease, chronic kidney disease, absence of the right kidney, or liver masses near the right kidney (35).

CAP, often performed alongside transient elastography (FibroScan), is a relatively new test validated in large studies for detecting various degrees of steatosis. However, the specialized equipment used for CAP is not versatile for other imaging purposes. The present study found a very weak correlation between

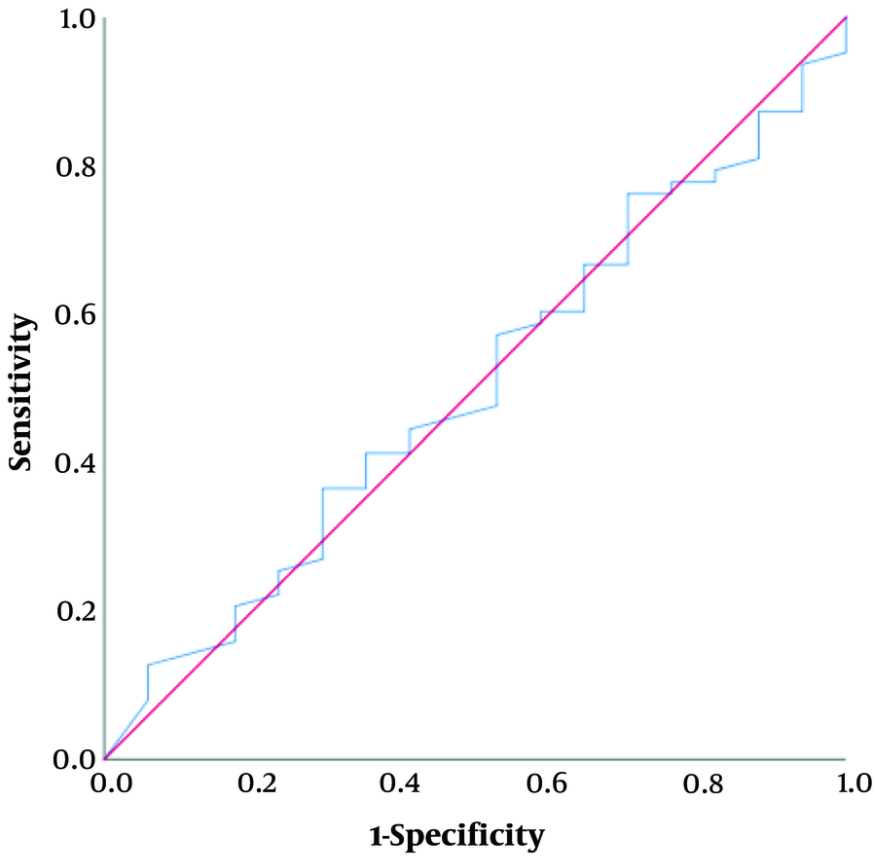

Figure 1. CAP score of fibroscan in diagnosing fatty liver

the hepatorenal index measured by elastography and CAP measured by liver fibroscan. Liver fibroscan results were not reliable for diagnosing fatty liver disease. Nevertheless, CAP scores alone may not be a good indicator for diagnosing fatty liver disease, especially without elastography steatosis scoring.

In this study, a weak correlation was observed between the CAP score and Ratio B-Mode. Kjaergaard et al. (29) found that Ratio B-Mode with CAP score was comparable in diagnostic accuracy, but it was highly susceptible to failure, limiting its clinical utility. A CAP is a semi-quantitative technique that is independent of the machine and operator and less affected by sampling error than a liver biopsy since it examines a much larger volume of liver (36). However, there is limited research on CAP is present in chronic liver disease patients and none in the general population.

Additionally, CAP is unavailable when using the XL probe, indicating a need for further development and validation (37).

In this study, a positive correlation was observed between liver enzymes (ALT and AST) and elastography findings. However, this correlation was not statistically significant. Furthermore, our results revealed that while AST could not predict fatty liver diagnosed by elastography, ALT demonstrated predictive capability with 83.6% sensitivity and 67.4% specificity.

Consistent with this study, Ayonrinde et al. (38) found a positive association between serum ALT and liver fibrosis diagnosed by elastography. However, liver biochemistry combining ALT without AST did not significantly correlate with liver fibrosis, corroborating our results. Similarly, Rasul et al. (39) reported no significant relationship between elastography fibrosis score and AST/ALT values in NAFLD patients, aligning

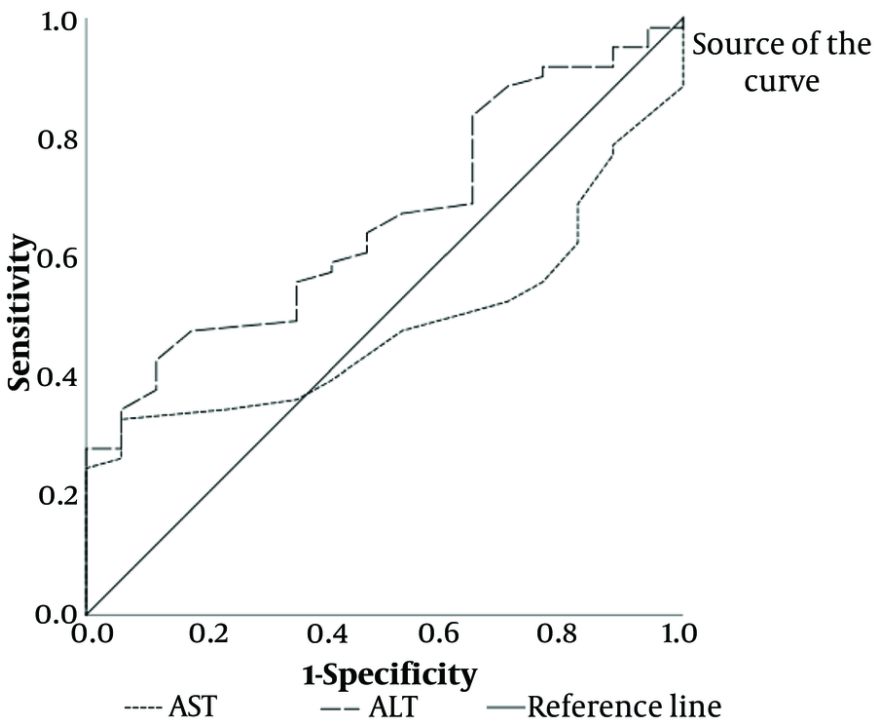

Figure 2. Area under the curve for liver enzyme findings in diagnosing fatty liver

with our findings. Feng et al. (40) demonstrated a strong correlation between SWE and liver function tests in severe fibrosis and cirrhosis. In contrast, Yoon et al. (41) reported a significant correlation between two-dimensional SWE and AST, ALT, and triglyceride-glucose index, differing from our findings. Risk factors such as metabolic syndrome, diabetes, and obesity, alongside elevated liver enzymes, increase the likelihood of NAFLD. However, ALT alone may not be reliable in predicting NAFLD (42, 43).

According to this study, elastography accurately diagnosed 78.8% of fatty liver patients identified by ultrasound, making it a useful noninvasive tool for diagnosing fatty liver disease. A significant correlation was not found between fibroscan findings and liver enzymes and elastography results, suggesting they may not be reliable indicators of fatty liver. No single method alone is sufficient for diagnosing and staging fatty. liver disease, and employing a combination of different methods may be more beneficial.

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Footnotes

Authors' Contribution: Study concept and design: M. F., Z. Gh., and P. J.; acquisition of data: P. J.; analysis and interpretation of data: M. N.; drafting of the manuscript: M. N.; statistical analysis: M. N.; study supervision: Z. Gh.

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Data Availability: The data that support the findings of this study are available from corresponding author upon reasonable request

Ethical Approval: IR.SUMS.MED.REC.1401.561 .

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References

1. Keating SE, Hackett DA, George J, Johnson NA. Exercise and non-alcoholic fatty liver disease: a systematic review and meta-analysis. *J Hepatol*. 2012;**57**(1):157-66. [PubMed ID: 22414768]. https://doi.org/10.1016/j.jhep.2012.02.023.
2. Iranikhah A, Hormati A, Shakeri M, Aghaali M. [Non-alcoholic fatty liver disease in Children]. *J Mazandaran Univ Med Sci*. 2018;**28**(165):230-42. FA.
3. Younossi Z, Tacke F, Arrese M, Chander Sharma B, Mostafa I, Bugianesi E, et al. Global Perspectives on Nonalcoholic Fatty Liver Disease and Nonalcoholic Steatohepatitis. *Hepatology*. 2019;**69**(6):2672-82. [PubMed ID: 30179269]. https://doi.org/10.1002/hep.30251.
4. Neuschwander-Tetri BA. Non-alcoholic fatty liver disease. *BMC Med*. 2017;**15**(1):45. [PubMed ID: 28241825]. [PubMed Central ID: PMC5330146]. https://doi.org/10.1186/s12916-017-0806-8.
5. Sattar N, Forrest E, Preiss D. Non-alcoholic fatty liver disease. *BMJ*. 2014;**349**:g4596. [PubMed ID: 25239614]. [PubMed Central ID: PMC4168663]. https://doi.org/10.1136/bmj.g4596.
6. Jamali R, Khonsari M, Merat S, Khoshnia M, Jafari E, Bahram Kalhori A, et al. Persistent alanine aminotransferase elevation among the general Iranian population: prevalence and causes. *World J Gastroenterol*. 2008;**14**(18):2867-71. [PubMed ID: 18473412]. [PubMed Central ID: PMC2710729]. https://doi.org/10.3748/wjg.14.2867.
7. Platon ML, Stefanescu H, Muresan D, Florea M, Szász ME, Maniu A. Noninvasive assessment of liver steatosis using ultrasound methods. *Med Ultrasonograph*. 2014;**16**(3):236-45. https://doi.org/10.11152/mu.2013.2066.163.1mlp.
8. Smith BW, Adams LA. Non-alcoholic fatty liver disease. *Crit Rev Clin Lab Sci*. 2011;**48**(3):97-113. [PubMed ID: 21875310]. https://doi.org/10.3109/10408363.2011.596521.
9. Tapper EB, Afdhal NH. Vibration-controlled transient elastography: a practical approach to the noninvasive assessment of liver fibrosis. *Curr Opin Gastroenterol*. 2015;**31**(3):192-8. [PubMed ID: 25730177]. https://doi.org/10.1097/MOG.0000000000000169.
10. Omran DA, Darweesh SK, Fouad H, Mahmoud M, Saif S, Fared A. Serum zinc deficiency and its relation to liver fibrosis in chronic HCV: a real-life Egyptian study. *Biological Trace Element Res*. 2017;**179**:1-6. https://doi.org/10.1007/s12011-017-0938-x.
11. Mateos-Munoz B, Devesa-Medina MJ, Matia-Martin MP, Torrejon MJ, Suarez A, Larrad-Sainz A, et al. The relation of fibrosis stage with nutritional deficiencies and bioelectrical impedance analysis of body composition in patients with chronic hepatitis C. *Ann Hepatol*. 2016;**15**(4):492-500. [PubMed ID: 27236148].
12. Vergniol J, Foucher J, Terrebonne E, Bernard PH, le Bail B, Merrouche W, et al. Noninvasive tests for fibrosis and liver stiffness predict 5-year outcomes of patients with chronic hepatitis C. *Gastroenterology*. 2011;**140**(7):1970-9. 1979 e1-3. [PubMed ID: 21376047]. https://doi.org/10.1053/j.gastro.2011.02.058.
13. da Silva LCM, de Oliveira JT, Tochetto S, de Oliveira C, Sigrist R, Chammas MC. Ultrasound elastography in patients with fatty liver disease. *Radiol Bras*. 2020;**53**(1):47-55. [PubMed ID: 32313337]. [PubMed Central ID: PMC7159044]. https://doi.org/10.1590/0100-3984.2019.0028.
14. Hassan K, Bhalla V, El Regal ME, A. Kader HH. Nonalcoholic fatty liver disease: a comprehensive review of a growing epidemic. *World J Gastroenterol*. 2014;**20**(34):12082-101. [PubMed ID: 25232245]. [PubMed Central ID: PMC4161796]. https://doi.org/10.3748/wjg.v20.i34.12082.
15. Johnson SI, Fort D, Shortt KJ, Therapondos G, Galliano GE, Nguyen T, et al. Ultrasound Stratification of Hepatic Steatosis Using Hepatorenal Index. *Diagnostics (Basel)*. 2021;**11**(8). [PubMed ID: 34441377]. [PubMed Central ID: PMC8391375]. https://doi.org/10.3390/diagnostics11081443.
16. Benedict M, Zhang X. Non-alcoholic fatty liver disease: An expanded review. *World J Hepatol*. 2017;**9**(16):715-32. [PubMed ID: 28652891]. [PubMed Central ID: PMC5468341]. https://doi.org/10.4254/wjh.v9.i16.715.
17. Webb M, Yeshua H, Zelber-Sagi S, Santo E, Brazowski E, Halpern Z, et al. Diagnostic value of a computerized hepatorenal index for sonographic quantification of liver steatosis. *AJR Am J Roentgenol*. 2009;**192**(4):909-14. [PubMed ID: 19304694]. https://doi.org/10.2214/AJR.07.4016.
18. Schwenzer NF, Springer F, Schraml C, Stefan N, Machann J, Schick F. Non-invasive assessment and quantification of liver steatosis by ultrasound, computed tomography and magnetic resonance. *J Hepatol*. 2009;**51**(3):433-45. [PubMed ID: 19604596]. https://doi.org/10.1016/j.jhep.2009.05.023.
19. Yokoo T, Bydder M, Hamilton G, Middleton MS, Gamst AC, Wolfson T, et al. Nonalcoholic fatty liver disease: diagnostic and fat-grading accuracy of low-flip-angle multiecho gradient-recalled-echo MR imaging at 1.5 T. *Radiology*. 2009;**251**(1):67-76. [PubMed ID: 19221054]. [PubMed Central ID: PMC2663579]. https://doi.org/10.1148/radiol.2511080666.
20. Lee DH. Imaging evaluation of non-alcoholic fatty liver disease: focused on quantification. *Clin Mol Hepatol*. 2017;**23**(4):290-301. [PubMed ID: 28994271]. [PubMed Central ID: PMC5760010]. https://doi.org/10.3350/cmh.2017.0042.
21. Lall CG, Aisen AM, Bansal N, Sandrasegaran K. Nonalcoholic fatty liver disease. *AJR Am J Roentgenol*. 2008;**190**(4):993-1002. [PubMed ID: 18356447]. https://doi.org/10.2214/AJR.07.2052.
22. Taru MG, Neamti L, Taru V, Procopciuc LM, Procopet B, Lupsor-Platon M. How to Identify Advanced Fibrosis in Adult Patients with Non-Alcoholic Fatty Liver Disease (NAFLD) and Non-Alcoholic Steatohepatitis (NASH) Using Ultrasound Elastography-A Review of the Literature and Proposed Multistep Approach. *Diagnostics (Basel)*. 2023;**13**(4). [PubMed ID: 36832276]. [PubMed Central ID: PMC9955630]. https://doi.org/10.3390/diagnostics13040788.
23. Ferraioli G, Wong VW, Castera L, Berzigotti A, Sporea I, Dietrich CF, et al. Liver Ultrasound Elastography: An Update to the World Federation for Ultrasound in Medicine and Biology Guidelines and Recommendations. *Ultrasound Med Biol*. 2018;**44**(12):2419-40. [PubMed ID: 30209008]. https://doi.org/10.1016/j.ultrasmedbio.2018.07.008.
24. Li DK, Khan MR, Wang Z, Chongsrisawat V, Swangsak P, Teufel-Schafer U, et al. Normal liver stiffness and influencing factors in healthy children: An individual participant data meta-analysis. *Liver Int*. 2020;**40**(11):2602-11. [PubMed ID: 32901449]. https://doi.org/10.1111/liv.14658.
25. Borges VF, Diniz AL, Cotrim HP, Rocha HL, Andrade NB. Sonographic hepatorenal ratio: a noninvasive method to diagnose nonalcoholic steatosis. *J Clin Ultrasound*. 2013;**41**(1):18-25. [PubMed ID: 22997020]. https://doi.org/10.1002/jcu.21994.
26. Dubois M, Ronot M, Houssel-Debry P, Brun V, Rayar M, Auger M, et al. Performance of B-mode ratio and 2D shear wave elastography for the detection and quantification of hepatic steatosis and fibrosis after liver transplantation. *Eur J Gastroenterol Hepatol*. 2020;**32**(2):222-30.

[PubMed ID: 31464783]. https://doi.org/10.1097/MEG.0000000000001500.

27. Stahlschmidt FL, Tafarel JR, Menini-Stahlschmidt CM, Baena CP. Hepatorenal index for grading liver steatosis with concomitant fibrosis. *PLoS One*. 2021;**16**(2). e0246837. [PubMed ID: 33577616]. [PubMed Central ID: PMC7880490]. https://doi.org/10.1371/journal.pone.0246837.
28. Kramer H, Pickhardt PJ, Kliewer MA, Hernando D, Chen GH, Zagzebski JA, et al. Accuracy of Liver Fat Quantification With Advanced CT, MRI, and Ultrasound Techniques: Prospective Comparison With MR Spectroscopy. *AJR Am J Roentgenol*. 2017;**208**(1):92-100. [PubMed ID: 27726414]. [PubMed Central ID: PMC5204456]. https://doi.org/10.2214/AJR.16.16565.
29. Kjaergaard M, Lindvig KP, Hansen CD, Detlefsen S, Krag A, Thiele M. Hepatorenal Index by B-Mode Ratio Versus Imaging and Fatty Liver Index to Diagnose Steatosis in Alcohol-Related and Nonalcoholic Fatty Liver Disease. *J Ultrasound Med*. 2023;**42**(2):487-96. [PubMed ID: 35475550]. [PubMed Central ID: PMC10084348]. https://doi.org/10.1002/jum.15991.
30. Moret A, Boursier J, Houssel Debry P, Riou J, Crouan A, Dubois M, et al. Evaluation of the Hepatorenal B-Mode Ratio and the "Controlled Attenuation Parameter" for the Detection and Grading of Steatosis. *Ultraschall Med*. 2022;**43**(5):479-87. [PubMed ID: 32992377]. https://doi.org/10.1055/a-1233-2290.
31. Chauhan A, Sultan LR, Furth EE, Jones LP, Khungar V, Sehgal CM. Diagnostic accuracy of hepatorenal index in the detection and grading of hepatic steatosis. *J Clin Ultrasound*. 2016;**44**(9):580-6. [PubMed ID: 27447717]. https://doi.org/10.1002/jcu.22382.
32. Petzold G, Lasser J, Ruhl J, Bremer SCB, Knoop RF, Ellenrieder V, et al. Diagnostic accuracy of B-Mode ultrasound and Hepatorenal Index for graduation of hepatic steatosis in patients with chronic liver disease. *PLoS One*. 2020;**15**(5). e0231044. [PubMed ID: 32357147]. [PubMed Central ID: PMC7194436]. https://doi.org/10.1371/journal.pone.0231044.
33. Marshall RH, Eissa M, Bluth EI, Gulotta PM, Davis NK. Hepatorenal index as an accurate, simple, and effective tool in screening for steatosis. *AJR Am J Roentgenol*. 2012;**199**(5):997-1002. [PubMed ID: 23096171]. https://doi.org/10.2214/AJR.11.6677.
34. Shiralkar K, Johnson S, Bluth EI, Marshall RH, Dornelles A, Gulotta PM. Improved method for calculating hepatic steatosis using the hepatorenal index. *J Ultrasound Med*. 2015;**34**(6):1051-9. [PubMed ID: 26014325]. https://doi.org/10.7863/ultra.34.6.1051.
35. Wang CC, Hsieh TC, Tseng TC, Wang PC, Hsu CS, Lin HH, et al. Factors affecting the diagnostic accuracy of ultrasonography in assessing the severity of hepatic steatosis. *J Formos Med Assoc*. 2014;**113**(4):249-54. [PubMed ID: 24685301]. https://doi.org/10.1016/j.jfma.2012.07.004.
36. Sasso M, Beaugrand M, de Ledinghen V, Douvin C, Marcellin P, Poupon R, et al. Controlled attenuation parameter (CAP): a novel VCTE guided ultrasonic attenuation measurement for the evaluation of hepatic steatosis: preliminary study and validation in a cohort of patients with chronic liver disease from various causes. *Ultrasound Med Biol*. 2010;**36**(11):1825-35. [PubMed ID: 20870345]. https://doi.org/10.1016/j.ultrasmedbio.2010.07.005.
37. Wong GL. Transient elastography: Kill two birds with one stone? *World J Hepatol*. 2013;**5**(5):264-74. [PubMed ID: 23717737]. [PubMed Central ID: PMC3664284]. https://doi.org/10.4254/wjh.v5.i5.264.
38. Ayonrinde OT, Zelesco M, Welman CJ, Abbott S, Adris N. Clinical relevance of shear wave elastography compared with transient elastography and other markers of liver fibrosis. *Intern Med J*. 2022;**52**(4):640-50. [PubMed ID: 34726820]. [PubMed Central ID: PMC9311739]. https://doi.org/10.1111/imj.15603.
39. Rasul SMS, Salim AK, Hussein HA. Correlation Between Point Shear Wave Elastography and Liver Function Tests as A Predictor of Liver Fibrosis in Patients with Nonalcoholic Fatty Liver Disease. *Pakistan Journal of Medical and Health Sciences*. 2021;**15**(6):1990-4. https://doi.org/10.53350/pjmhs211561990.
40. Feng YH, Hu XD, Zhai L, Liu JB, Qiu LY, Zu Y, et al. Shear wave elastography results correlate with liver fibrosis histology and liver function reserve. *World J Gastroenterol*. 2016;**22**(17):4338-44. [PubMed ID: 27158202]. [PubMed Central ID: PMC4853691]. https://doi.org/10.3748/wjg.v22.i17.4338.
41. Yoon JS, Lim KJ, Hwang IT. Usefulness of two-dimensional shear wave elastography in the assessment of non-alcoholic fatty liver disease in children and adolescents. *Sci Rep*. 2023;**13**(1):10062. [PubMed ID: 37344574]. [PubMed Central ID: PMC10284908]. https://doi.org/10.1038/s41598-023-37281-z.
42. Noureddin M, Loomba R. Nonalcoholic fatty liver disease: Indications for liver biopsy and noninvasive biomarkers. *Clin Liver Dis (Hoboken)*. 2012;**1**(4):104-7. [PubMed ID: 31186861]. [PubMed Central ID: PMC6499277]. https://doi.org/10.1002/cld.65.
43. Rafiq N, Bai C, Fang Y, Srishord M, McCullough A, Gramlich T, et al. Long-term follow-up of patients with nonalcoholic fatty liver. *Clin Gastroenterol Hepatol*. 2009;**7**(2):234-8. [PubMed ID: 19049831]. https://doi.org/10.1016/j.cgh.2008.11.005.