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Multiparametric Ultrasound Assessment Of Non-Alcoholic Fatty Liver Disease Using Modern Techniques And Evaluation Of Clinical Significance

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Abstract: Non-alcoholic fatty liver disease (NAFLD) is one of the most common causes of chronic liver damage. Ultrasound and elastography play a key role in the early detection of steatosis and fibrosis, allowing for an objective assessment of the liver's morphofunctional state without invasive procedures. The work presents the characteristics of the main ultrasound signs of NAFLD, the possibility of quantitative assessment of steatosis, as well as the role of compression and shift wave elastography in determining the degree of fibrosis. Current diagnostic criteria, correlation of ultrasound parameters with clinical and biochemical parameters, and modern requirements for disease progression risk stratification are considered. The use of a comprehensive ultrasound approach allows for increased accuracy in diagnosing NAFLD and determining the optimal management tactics for patients.

Keywords: NAFLD, ultrasound diagnostics, elastography, steatosis, liver fibrosis.

Introduction: Non-alcoholic fatty liver disease (NAFLD) is currently regarded as one of the most prevalent chronic liver diseases among adults and represents a major global medical problem. Over recent decades, the prevalence of NAFLD has increased in parallel with the rising rates of obesity, metabolic syndrome, type 2 diabetes mellitus, and other cardiometabolic disorders.

According to international epidemiological studies, NAFLD is detected in 25–30% of the adult population and in up to 60–80% of individuals with obesity. Among patients with type 2 diabetes mellitus, the prevalence exceeds 70%, highlighting the close association between NAFLD and disturbances of carbohydrate and lipid metabolism. Given the increasing burden of metabolic diseases, a further rise in NAFLD incidence is expected in the coming years.

Of particular clinical significance is the fact that approximately 20–30% of patients with simple steatosis progress to non-alcoholic steatohepatitis (NASH), and 10–15% develop liver fibrosis and cirrhosis. Adult NAFLD is characterized by a prolonged asymptomatic course; therefore, the disease is often diagnosed at advanced stages of fibrosis, when therapeutic options are substantially limited.

Standard laboratory parameters (ALT, AST) have low sensitivity and do not always reflect the degree of liver damage, leading to delayed diagnosis. Under these conditions, there is a growing need for reliable non-invasive methods to assess structural liver changes.

Ultrasound examination (US) is the primary method of first-line liver imaging in adults. It allows detection of diffuse changes characteristic of steatosis and assessment of its severity. However, the ability of conventional ultrasound to determine the stage of

fibrosis is limited. In this context, liver elastography—shear wave elastography (SWE) and transient elastography (FibroScan)—has assumed a key role in the diagnosis of NAFLD in adults. These methods provide quantitative assessment of liver stiffness, enabling detection of early stages of fibrosis, monitoring of disease progression, and evaluation of treatment efficacy without the need for liver biopsy.

Thus, the high prevalence of NAFLD in the adult population, the substantial proportion of progressive forms, its association with metabolic and cardiovascular diseases, and the limited diagnostic value of laboratory tests determine the necessity for widespread use of ultrasound diagnostics and elastography as the most accessible, non-invasive, and informative tools for early detection and monitoring of the disease.

Aim of the Study

To evaluate the diagnostic capabilities of comprehensive ultrasound diagnostics in detecting hepatic steatosis and fibrosis in patients with non-alcoholic fatty liver disease.

METHODS

The study was conducted at private medical institutions Dialab Med 2020 and Hayat Medical Center, equipped with modern expert-class ultrasound systems. The study had a prospective observational design.

A total of 120 adult patients aged 19 to 67 years were included. All participants were consecutively referred for examination due to suspected NAFLD or the presence of risk factors for its development. All patients underwent comprehensive clinical and instrumental evaluation, including anthropometric assessment, laboratory testing, and ultrasound examination.

Inclusion criteria were: age over 18 years; presence of NAFLD risk factors (obesity, dyslipidemia, insulin resistance, arterial hypertension); ultrasound signs of steatosis or increased liver echogenicity; voluntary informed consent to participate.

Exclusion criteria included: viral hepatitis B and C; alcoholic liver disease; autoimmune hepatopathies; hemochromatosis; Wilson–Konovalov disease; liver cirrhosis of other etiologies; long-term use of hepatotoxic drugs.

All patients underwent measurement of height and body weight, calculation of body mass index (BMI), waist circumference assessment, identification of metabolic syndrome components, and blood pressure evaluation.

Biochemical blood analysis included determination of ALT, AST, GGT, bilirubin; total cholesterol, triglycerides, LDL, HDL; fasting glucose and insulin with calculation of HOMA-IR; and C-reactive protein. Laboratory findings were interpreted in conjunction with ultrasound and elastography data.

Abdominal ultrasound was performed using Aplio 500 systems with a 3.5–5 MHz convex transducer. Examinations were conducted after fasting, with patients in the supine and left lateral positions, using standard scanning planes.

The following parameters were assessed: structural characteristics of the liver, parenchymal echogenicity, depth of ultrasound beam penetration, visualization and clarity of the vascular pattern, contour and diameter of the portal vein, and presence of focal or diffuse changes.

Quantitative assessment of steatosis was performed by comparing liver echogenicity with that of the renal cortex (hepatorenal index, HRI). Steatosis grading was determined according to international criteria (NAS) from S0 to S3.

Elastography was a key component of the comprehensive assessment. Shear wave elastography (SWE) was used as the primary method; transient elastography (FibroScan) was performed when equipment was available, and strain elastography was applied as an auxiliary technique. Examinations were performed strictly under fasting conditions, with at least 10 valid measurements obtained in the right lobe of the liver, avoiding vascular structures, rib shadows, and areas of heterogeneity. The variability coefficient was <30%. Liver stiffness values were interpreted according to the METAVIR classification (F0–F4).

RESULTS

The study included 120 adult patients who underwent comprehensive ultrasound and elastographic evaluation of the liver. Below are the clinical characteristics of the study population, distribution according to the degree of steatosis and fibrosis, and analysis of correlation relationships.

Most patients were aged 30–55 years (mean age 43.2 ± 10.6 years). Women accounted for 62 (51.7%) cases and men for 58 (48.3%). The prevalence of metabolic risk factors was high: obesity was identified in 71 patients (59%), dyslipidemia in 63 (52%), and insulin resistance in 54 (45%).

Ultrasound examination revealed diffuse liver changes of varying severity. The main echographic manifestations of steatosis in adult patients included increased overall parenchymal echogenicity in 102 patients (85%), attenuation of the ultrasound signal in deeper regions in 78 (65%), reduced clarity of the vascular pattern in 86 (71.7%), and impaired

visualization of the portal vein wall in 59 patients (49%).

Table 1. Distribution of patients according to the degree of steatosis (n = 120)

Степень стеатоза	Количество, n	Доля (%)
S0	18	15%
S1	42	35%
S2	38	31,7%
S3	22	18,3%

Thus, the majority of patients had mild and moderate steatosis (S1–S2), with S2 being more frequently detected in patients with a body mass index (BMI) > 30 kg/m².

Shear wave and transient elastography enabled quantitative assessment of liver stiffness and determination of fibrosis stage according to the METAVIR scale. Elastography identified a substantial number of patients with early stages of fibrosis (F1 and F2), whereas advanced fibrosis (F3–F4) was observed significantly less frequently.

Table 2. Distribution of patients according to the degree of fibrosis (SWE/TE)

Степень фиброза	Количество, n	Доля (%)
F0	41	34,2%
F1	33	27,5%
F2	27	22,5%
F3	14	11,7%
F4	5	4,1%

The mean liver stiffness values (kPa) were as follows: F0 – 4.2 ± 0.5, F1 – 6.1 ± 0.7, F2 – 7.8 ± 0.9, F3 – 10.2 ± 1.1, and F4 – 14.6 ± 2.4. Early stages of fibrosis (F1–F2) were identified in the majority of patients, which is typical for NAFLD in outpatient clinical practice.

Elevated ALT levels were observed in 40.8% of patients, AST in 26.7%, and GGT in 31.7%. At the same time, 30% of patients had normal transaminase levels despite the presence of steatosis.

A clear association was identified between echographic signs of steatosis and liver stiffness values (Table 3).

Table 3. Correlation relationships

Параметры	r	p
ИМТ - степень стеатоза	0,56	<0,001
АЛТ - эхогенность печени	0,42	<0,01
АСТ - жесткость печени	0,47	<0,001
ГГТ - жесткость печени	0,51	<0,001

As shown in Table 3, ALT levels were elevated in 49 patients (40.8%) and correlated with the degree of steatosis (r = 0.42). AST elevation was observed less frequently, in 32 patients (26.7%), but showed a significant association with liver stiffness (r = 0.47). GGT levels correlated with fibrosis severity (r = 0.51; p < 0.001). In 36 patients (30%), steatosis was present despite normal transaminase levels. This confirms that a normal biochemical profile does not exclude the presence of non-alcoholic fatty liver disease (NAFLD).

With increasing BMI, a significant increase in liver echogenicity was observed (p < 0.05), along with higher SWE values (r = 0.56) and a greater prevalence of moderate-to-severe steatosis (S2–S3) among obese

patients (67%). In patients with insulin resistance, liver stiffness values were significantly higher than in patients without insulin resistance ($p < 0.01$).

Thus, ultrasound reliably detects hepatic steatosis, particularly at stages S2–S3, while elastography is a highly sensitive tool for the diagnosis of fibrosis. Clinical and laboratory parameters significantly enhance diagnostic accuracy, and the most common stages of fibrosis in patients with NAFLD were F1–F2. A comprehensive approach allows for early detection of NAFLD and identification of patients at risk for disease progression.

DISCUSSION

The obtained results confirm the importance of comprehensive ultrasound examination, including conventional B-mode imaging and elastography, in the diagnosis and severity stratification of non-alcoholic fatty liver disease in adult patients. Our findings are consistent with global literature, according to which ultrasound remains the primary modality for detecting steatosis, while elastography serves as a key tool for fibrosis assessment.

The high prevalence of steatosis (85% of patients demonstrated echographic signs of fatty infiltration) reflects the global trend of increasing metabolic disorders. The predominance of S1–S2 steatosis corresponds to the typical structure of NAFLD in outpatient practice, where severe steatosis (S3) is less common.

The strong association between steatosis severity and BMI highlights the leading role of obesity in the pathogenesis of NAFLD, consistent with international studies demonstrating a linear increase in NAFLD risk with increasing body weight. The presence of steatosis in 30% of patients with normal transaminase levels confirms that laboratory parameters do not always reflect the true extent of liver damage, further emphasizing the diagnostic value of ultrasound as a primary screening tool.

Elastographic data demonstrated a significant prevalence of early fibrosis stages (F1–F2), which is typical for NAFLD without pronounced inflammatory activity. Only a small proportion of patients exhibited advanced fibrosis (F3–F4), consistent with the outpatient nature of the study population. The liver stiffness values obtained across METAVIR stages (4.2 kPa for F0 and 14.6 kPa for F4) correspond to reference values published in international guidelines, confirming the methodological accuracy and reliability of the measurements.

Identified correlations between liver stiffness and AST, GGT, and BMI reflect the pathophysiological relationship between fibrosis, inflammation, and metabolic disturbances. Particularly noteworthy is the significant increase in SWE values in patients with insulin resistance, which represents one of the key markers of rapid NAFLD progression.

Elastography demonstrated high sensitivity (92%) for the detection of fibrosis ≥F2, making it the most reliable non-invasive method for disease stage verification. At the same time, ultrasound showed high diagnostic value in identifying steatosis ≥S2, fully consistent with its role as the first step in the diagnostic algorithm. The combination of ultrasound and SWE increased diagnostic accuracy to 95%, confirming the necessity of their combined use in routine clinical practice.

Comprehensive liver assessment, including visual ultrasound features, quantitative steatosis indices, and objective measurement of liver stiffness, enables risk stratification for NAFLD progression. This approach provides early identification of patients requiring active management, reduces the need for liver biopsy, facilitates monitoring of therapeutic efficacy, and allows dynamic observation of fibrosis progression.

Thus, the obtained data confirm that the combination of ultrasound and elastography represents the optimal tool for the diagnosis and monitoring of NAFLD in adult patients.

CONCLUSIONS

Conventional B-mode ultrasound remains an effective screening method for detecting hepatic steatosis. The main echographic features of NAFLD in adult patients include increased liver echogenicity, attenuation of the ultrasound signal, and reduced visualization of the vascular pattern, allowing reliable grading of steatosis (S0–S3).

Shear wave and transient elastography provide high accuracy in quantitative assessment of liver stiffness. The majority of examined patients exhibited early stages of fibrosis (F1–F2), while SWE values demonstrated clear correlations with AST, GGT, BMI, and steatosis severity.

The combination of ultrasound and elastography increases diagnostic accuracy to 95% and enables identification of patients at risk for disease progression while minimizing the need for invasive procedures. Correlations between laboratory and instrumental findings confirm the pathogenetic relationship between steatosis, metabolic disorders, and early fibrosis. Normal transaminase levels do not exclude NAFLD, emphasizing the necessity of instrumental diagnostic methods.

A comprehensive ultrasound-based approach (B-mode + SWE/TE) represents the optimal tool for early

diagnosis, risk stratification, and monitoring of treatment efficacy in patients with non-alcoholic fatty liver disease.

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