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THE ROLE OF MODERN ULTRASONIC METHODS IN THE DIAGNOSIS OF LIVER FAT INFILTRATION: METHODOLOGICAL ASPECTS

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Abstract. Fatty infiltration of the liver (steatosis, steatohepatosis) is a chronic disease characterized by excessive accumulation of triglycerides in hepatocytes, which leads to disruption of intrahepatic metabolic processes and the formation of progressive structural and functional changes in the liver parenchyma. According to epidemiological studies, the prevalence of metabolically associated fatty liver disease (MASD) in the general population reaches 25-30%, and among patients with obesity and type 2 diabetes mellitus exceeds 60-70%, which determines the high medical and social significance of this pathology. Modern ultrasound technologies have proven themselves as a non-invasive, safe, and accessible method for the primary diagnosis of liver diseases. The use of multiparametric ultrasound, including scale scanning, Doppler ultrasound, and elastography, significantly expands the diagnostic capabilities of ultrasound. A comprehensive ultrasound approach allows increasing the accuracy of detecting fatty liver infiltration, conducting differential diagnosis of diffuse diseases, and more objectively assessing the degree of fibrous changes, which is of fundamental importance for risk stratification and choosing the optimal management tactics for patients.

Keywords: fatty infiltration of the liver; steatohepatosis; ultrasound diagnostics; multiparametric ultrasound examination; liver elastography; shear wave elastography; liver fibrosis; diffuse liver diseases; non-invasive diagnostics.

Relevance. Fatty liver infiltration as a distinct clinical entity was identified in the 1960s with the introduction of liver biopsy into clinical practice. This condition is characterized by the pathological accumulation of lipid inclusions, either intracellular or extracellular, in hepatocytes, leading to metabolic disruption and structural remodeling of the liver parenchyma. Detection and quantification of fatty infiltration are crucial for planning treatment strategies for viral and other diffuse liver diseases.

Liver biopsy is traditionally considered the "gold standard" for diagnosing steatosis and fibrosis. However, this method is invasive and carries a risk of pain, bleeding, and other complications, limiting its widespread use and repeated use in patient follow-up.

The concept of fatty liver disease is now clearly defined and encompasses a wide range of pathological conditions, including simple fatty degeneration (liver steatosis), steatosis with inflammation and hepatocyte damage (metabolic-associated steatohepatitis), and fibrosis with possible progression on the METAVIR scale from F0 to F3, ultimately leading to cirrhosis (F4). Fatty liver infiltration is rightfully considered one of the most pressing and dynamically developing issues in modern gastroenterology.

In its pathogenetic development, fatty hepatosis goes through three main stages: simple fatty degeneration of the liver without pronounced destruction of hepatocytes; fatty infiltration combined with necrobiosis of hepatocytes; fatty infiltration with initial restructuring of the lobular architecture of the liver, considered as the precirrhotic stage.

The aim of this study is to analyze the methodological aspects and evaluate the diagnostic advantages and limitations of a comprehensive liver ultrasound examination, including elastography, in patients with fatty liver infiltration.

When performing a liver ultrasound, it is important to follow standard patient preparation, including a fasting examination. In grayscale mode (B-mode), ultrasound signs of fatty liver infiltration include enlarged liver, rounded inferior margins, relatively uniform parenchymal

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structure, increased echogenicity, decreased sound conductivity, and decreased vascularity in the deep liver.

There are three forms of fatty liver disease: diffuse, localized, and focal. Depending on the severity of ultrasound changes, three degrees of fatty liver infiltration are distinguished.

In grade I, the liver is typically not enlarged or is enlarged by no more than 10–20 mm. The capsule is visualized as a thin hyperechoic line, and the parenchyma structure remains homogeneous with a moderate increase in echogenicity . A slight decrease in sound conductivity is noted, with up to 30% of the parenchyma in the subdiaphragmatic regions being less clearly visualized. Vascular patterns are generally preserved.

In grade II, the liver enlarges by 20–30 mm, and its lower edges become blunted. The liver capsule appears as a thin, hyperechoic line. Parenchyma echogenicity is significantly increased, the vascular pattern is poor, and a pronounced dorsal attenuation of the ultrasound signal appears. In areas distant from the transducer, up to 50% of the liver parenchyma (up to the level of the portal vein) is poorly visualized, and the diaphragm is poorly defined.

In grade III, the liver edges are sharply rounded, and the capsule is poorly visualized. Parenchyma echogenicity is greatly increased, and vascular patterns are virtually invisible ("liver as if through milk"). Dorsal attenuation is pronounced: the diaphragm is not visualized, and in the deep sections, up to 70% of the liver parenchyma is virtually undetectable.

The expansion of the multiparametric ultrasound protocol to include elastography has provided an additional opportunity to quantitatively assess the deformation properties of liver tissue by analyzing the propagation velocity of shear waves induced by a focused ultrasound pulse. In recent years, ultrasound elastography has established itself as an effective, noninvasive, and reproducible method for assessing liver stiffness and the extent of fibrotic changes.

Modern ultrasound systems support various elastography technologies (ELASTO), allowing for the measurement of a wide range of parameters related to tissue mechanical properties. The choice of a specific elastography method should be based on its physical principles, diagnostic capabilities, and clinical objectives. Generally, ultrasound elastography methods are divided into two main groups: static (deformation) and dynamic, based on the use of shear waves. These techniques differ in the nature of the external mechanical impact on tissue and their informativeness in assessing fibrotic changes in the liver.

Strain-based elastography, better known as compression elastography, is based on recording tissue changes in response to external mechanical forces that cause compression. Compression can be achieved by applying moderate pressure with an ultrasound transducer or by physiological movements such as vascular pulsation or respiratory excursions. The resulting data reflects the relative differences in stiffness between different areas of the study area.

The results of compression elastography are presented as a color elastogram or graphic display. However, this method does not provide a quantitative expression of tissue stiffness in absolute terms. The assessment is comparative in nature and only allows for an assessment of the distribution of stiffer and softer areas within the area of interest.

Advantages of the method: the ability to evaluate a relatively large area of liver parenchyma (on average up to 2.5 × 2.5 cm); the availability of the technique and the ability to perform it on standard ultrasound machines without the need for specialized equipment.

Limitations and disadvantages of the method: the inability to obtain quantitative tissue stiffness indicators in numerical terms; difficulty in obtaining reproducible results in patients with obesity and cardiovascular diseases; a decrease in the sensitivity of the method with increasing depth of the study area; pronounced operator dependence due to the influence of the compression force and the correct positioning of the sensor, which can lead to the appearance of noise and artifacts due to excessive pressure or incorrect technique.

Shear wave elastography utilizes transverse elastic waves, which propagate primarily in solid media. The excitation source is an ultrasound transducer, generating an acoustic longitudinal wave that propagates through the tissue. Its propagation velocity is higher in stiffer tissues compared to intact liver parenchyma. The interaction of the longitudinal wave with the tissue generates transverse shear waves, which have a slower propagation velocity and are more sensitive to changes in the tissue's mechanical properties.

The shear wave propagation velocity is the primary measurable parameter in elastography: the higher the velocity, the greater the tissue stiffness. All methods based on shear wave recording provide a quantitative assessment of tissue elasticity, which is their fundamental advantage over deformation-based methods.

Liver elastography results are expressed in kilopascals (kPa) and typically represent the average of a series (at least 10) of valid measurements taken in a given region of interest. The resulting values are compared to the METAVIR scale, with the caveat that threshold values may vary depending on the ultrasound equipment manufacturer and the technology used:

F0 (≤ 5.8 kPa) - no fibrosis;

F1 (5.9–7.2 kPa) – stellate expansion of the portal tracts without the formation of septa;

F2 (7.3–9.5 kPa) – expansion of portal tracts with single portoportal septa;

F3 (9.6–12.5 kPa) – multiple portocentral septa without signs of cirrhosis;

F4 (≥ 12.5 kPa) - liver cirrhosis.

Advantages of the method: the ability to perform the examination on standard ultrasound machines equipped with the ELASTO SWE option; an expanded examination area freely selectable by the physician ; and the presence of a color elastographic map, allowing for a visual assessment of tissue stiffness distribution.

Limitations and disadvantages of the method include: significant development of subcutaneous fat in the patient; shortness of breath and the inability to adequately hold one's breath during the examination; differences in reference values and calculation algorithms between ultrasound systems from different manufacturers, which complicates interdevice comparison of results.

The main criteria for selecting instrumental diagnostic methods remain their information content, availability, potential safety, and cost-effectiveness ratio. Timely and adequate assessment of the severity of the pathological process in the liver parenchyma is fundamental for determining the stage of the disease, prognosis, and selection of optimal patient management.

Transabdominal Grayscale ultrasound combined with liver elastography provides an objective basis for interpreting clinical data, including physical examination findings. Elastographic parameters reflect the degree of fibrotic changes in the liver; however, to improve the diagnostic accuracy and reproducibility of noninvasive methods, their combined use is advisable, increasing the sensitivity and specificity of diagnosing diffuse liver diseases.

Conclusion. A comprehensive assessment of the diagnostic capabilities, advantages, and limitations of individual ultrasound techniques - Grayscale ultrasound, Doppler ultrasound, and elastography are of great practical importance for fatty liver infiltration of varying degrees. Rational use of each of these modes and their combinations allows for increased accuracy in interpreting ultrasound data, objectively assessing the extent of liver parenchymal damage, and conducting differential diagnosis with other diffuse liver diseases. This, in turn, facilitates a more informed choice of patient management tactics and timely adjustments to treatment measures.

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