Anatomical And Physiological Features And Ultrasonic Diagnostics Of The Hepatobiliary System (Literature Review).

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ABSTRACT

The review systematizes modern data on the anatomical and physiological features of the hepatobiliary system in individuals of different ages, sexes and somatotypes. The article considers the morphological and functional characteristics of the liver, gallbladder and bile ducts in the norm and with normal variants. Particular attention is paid to the influence of age and gender differences, as well as somatotypic factors on the size, volume and functional activity of the organs of the hepatobiliary complex. The article highlights the modern possibilities of ultrasound diagnostics as a leading non-invasive visualization method that allows assessing the structural and functional parameters of organs in dynamics, conducting early diagnostics of diseases and monitoring the effectiveness of therapy. The article provides data on normal ultrasound parameters, their variability, as well as criteria for assessing deviations, which is important in clinical practice. The relevance of further research aimed at improving the methods of individualized assessment of the hepatobiliary system, taking into account the constitutional characteristics of patients, is noted.

Keywords: *hepatobiliary system, anatomical and physiological features, ultrasound diagnostics, age and gender differences, somatotype, morphometry, visualization.*

Introduction. The liver is one of the largest organs in the human body and the main gland involved in metabolic processes, detoxification, and production of proteins and hormones. The organ is located in the right hypochondrium and under the diaphragm. The liver in an adult weighs from 1.5 to 2 kg, and its size and shape vary depending on the age, sex, and body type of the person [4]. The liver is divided into two main lobes - right and left, and additional smaller ones - caudate and square, which are visible on the lower surface [18]. In children, the size of the liver depends on age and body weight, for example, in a 5-year-old child, the length of the right lobe is about 8-10 cm. Liver size indicators can also vary depending on ethnic characteristics, which must be taken into account when conducting an ultrasound examination [53].

The right lobe of the liver is significantly larger than the left and accounts for about 60-70% of the total volume of the organ. According to ultrasound, the normal size of the right lobe of the liver in the anteroposterior direction is 13-15 cm, and the left lobe is usually 7-10 sm in height and 5-7 sm in thickness. The contours of the liver are usually smooth and clear, which ensures excellent visualization during ultrasound examination [26].

Each lobe of the liver is divided into segments, eight in total, which allows for detailed local examination of individual parts of the organ. The segmental structure of the liver is based on the distribution of vessels and bile ducts, which determine the blood supply and function of various parts of the organ. Such segmental anatomy is important when planning surgical interventions, as it allows for minimizing damage and effectively removing affected areas in pathological conditions [45].

The liver consists of functional units, lobules, each of which includes hepatocytes surrounding the central vein. Hepatocytes, the main cells of the liver, are actively involved in metabolic processes, including protein synthesis, regulation of blood sugar and lipid levels, and detoxification of toxins. The liver lobules are hexagonal in shape and are surrounded by a portal triad consisting of a branch of the portal vein, a branch of the hepatic artery, and a bile duct. Hepatocytes are arranged in layers around the central vein, forming a structure that provides optimal conditions for metabolism [40].

The liver sinusoids, located between the layers of hepatocytes, contain Kupffer cells, specialized macrophages responsible for phagocytosis and immune defense. Kupffer cells play an important role in blood filtration, ensuring the removal of toxins, microbes, and damaged blood cells. The combination of hepatocytes and Kupffer cells forms a unique environment where blood detoxification and metabolism of various substances occurs [40].

The intrahepatic bile ducts originate from hepatocytes and join to form the common bile ducts, through which bile enters the gallbladder [20].

The vascular system of the liver plays a key role in its functions. The liver receives blood through the portal vein and the hepatic artery, which supplies it with oxygen and nutrients. Venous blood, rich in nutrients, passes through a system of capillaries and sinusoids, allowing the liver to effectively filter and process blood components [22].

The blood supply to the liver is provided by two main sources: the portal vein (v. portae) and the hepatic artery (a. hepatica). The portal vein brings 70-80% of the blood to the liver, while the hepatic artery brings 20-30%. The portal vein, which collects blood from the gastrointestinal tract, pancreas and spleen, provides the liver with nutrients, and the hepatic artery supplies arterial blood saturated with oxygen [52].

Once in the liver, blood is distributed through sinusoids, capillary vessels, where it comes into contact with hepatocytes, providing metabolism and absorption of nutrients. Venous blood then enters the central veins of the liver lobules, merging into the hepatic veins, which empty into the inferior vena cava, providing venous outflow from the liver. This system of blood supply and venous outflow is a key element in allowing the liver to perform its filtration and metabolic functions [75].

The pancreas is an elongated organ that performs both endocrine and exocrine functions. The gland consists of a head, body, and tail and is located behind the stomach in the upper abdominal cavity, extending to the spleen. The head of the pancreas is located in the arch of the duodenum, the body crosses the midline of the abdomen and is located at the level of the first lumbar vertebra, and the tail reaches the hilum of the spleen [28]. The exocrine function of the pancreas is to produce digestive enzymes such as lipase, amylase, and protease, which enter the duodenum and participate in the breakdown of fats, carbohydrates, and proteins [35].

The size of the pancreas may vary depending on age and body type. Normally, the length of the pancreas is from 12 to 20 sm, and the thickness depends on its area: the head on average has dimensions from 2.5 to 3.5 sm, the body - 1.5-2.5 sm, and the tail - up to 3 sm. These dimensions may change slightly with age, since over the years atrophic processes are possible, leading to a decrease in the thickness of the organ [19].

The pancreas is surrounded by a connective tissue capsule that protects it from mechanical damage and limits the spread of inflammatory processes. The capsule forms partitions dividing the gland into lobules. The main excretory duct of the pancreas, or Wirsung's duct, passes through the entire organ and joins the common bile duct before entering the duodenum, where it secretes enzymes for digestion [54].

The endocrine part of the pancreas is represented by the islets of Langerhans, which secrete hormones that regulate blood sugar levels. The main hormones, insulin and glucagon, play a critical role in maintaining glucose homeostasis. Disturbances in pancreatic function can lead to diseases such as diabetes mellitus and pancreatitis, which emphasizes the importance of its physiological state [60].

At the microscopic level, the pancreas consists of acinar cells that form acini, which secrete enzymes, and the islets of Langerhans, which perform endocrine functions. The acini are pyramidal in shape and are located around small ducts that receive enzymes. The islets of Langerhans are round structures scattered throughout the gland and are composed of several types of cells that perform different hormonal functions [35].

The main pancreatic duct (Wirsung's duct) runs along the entire length of the gland, receiving small excretory ducts from the acini along its entire length. The Wirsung's duct joins the common bile duct and opens into the duodenum in the region of the major duodenal papilla, through which enzymes enter the intestine for digestion [54].

In children, the size of the pancreas is significantly smaller than in adults. At the age of up to 5 years, the head of the pancreas has an average size of about 1.5-2 sm, the body - 1-1.5 sm, the tail - about 1.5 sm. These sizes increase with age and reach adult values by 15-18 years. In children, the size of the pancreas also varies depending on body weight and height, which must be taken into account when interpreting ultrasound data [9]. With age, the size of the gland may decrease somewhat due to tissue atrophy, which is a normal aging process and does not indicate pathology [56].

The bile duct and hepatic duct are the system that transports bile from the liver to the duodenum. Bile is produced in the liver and stored in the gallbladder until it is released into the intestines during digestion. In the liver, bile capillaries collect bile and pass it into larger ducts that then form the common hepatic duct and common bile duct. Bile is essential for the emulsification of fats and the absorption of fat-soluble vitamins such as A, D, E, and K, making it an important component of the digestive system [2].

The bile and hepatic ducts form a complex network inside and outside the liver, providing transport of bile, which is necessary for the process of digestion and absorption of fats. The main elements of the biliary system are the intrahepatic and extrahepatic ducts, which unite and form the common bile duct, or common bile duct, which flows into the duodenum. The bile duct system is structurally and functionally divided into intrahepatic and extrahepatic parts, each of which has its own characteristics and parameters [21].

The intrahepatic bile ducts begin as the smallest bile capillaries surrounding the hepatocytes in the liver lobules. These capillaries merge to form interlobular ducts, which in turn unite to form larger segmental ducts. As they exit the liver, they join to form the right and left hepatic ducts, which exit the liver and join to form the common hepatic duct. This duct, together with the cystic duct, forms the common bile duct, which opens into the duodenum [54].

Intrahepatic ducts are located in the liver parenchyma and are divided into small and large. Small ducts are formed at the level of bile capillaries located between hepatocytes. These capillaries unite into larger ducts that pass through the interlobular septa, gradually merging into segmental ducts. Normally, intrahepatic ducts have a diameter of less than 2 mm, which makes them difficult to distinguish during ultrasound examination. In pathology, such as obstruction or cholestasis, these ducts can expand, which becomes a diagnostic sign of disorders in the biliary system [3].

At the level of the porta hepatis, the segmental ducts unite to form the right and left hepatic ducts, which carry bile from the corresponding lobes of the liver. These ducts pass through the connective tissue of the porta hepatis and join outside the liver to form the common hepatic duct. The diameter of the right and left hepatic ducts is normally about 3-4 mm in adults. The size of the ducts may vary slightly depending on age, sex, and body type [46].

The extrahepatic bile ducts include the common hepatic duct and the cystic duct, which join to form the common bile duct (choledoch). The common hepatic duct leaves the liver and joins with the cystic duct, which drains bile from the gallbladder. The resulting common bile duct passes through the head of the pancreas and opens into the duodenum in the region of the major duodenal papilla [67-69].

The diameter of the common bile duct in adults ranges from 4 to 6 mm, although in older people it can expand to 7-8 mm, which is a normal age-related change. An increase in the diameter of the common bile duct over 8 mm may indicate obstruction or inflammation. In people who have undergone cholecystectomy, the diameter of the duct can increase to 10 mm due to the absence of a reservoir for bile, which was the gallbladder [42].

important for the normal functioning of the biliary system . The sphincter of Oddi consists of smooth muscle tissue that controls the opening and closing of the duct, preventing reflux of intestinal contents into the bile ducts and regulating the release of bile into the intestine in response to food intake. Secretion of hormones such as cholecystokinin stimulates relaxation of the sphincter of Oddi and the release of bile for the digestion process [29].

Bile, produced by the liver, plays an important role in digestion, participating in the emulsification of fats and the absorption of fat-soluble vitamins (A, D, E, K). The bile ducts transport bile from the liver to the duodenum, passing through the gallbladder, where bile can be stored and concentrated. During digestion, the gallbladder contracts, releasing bile into the intestine through the bile ducts, which ensures the absorption of fats and fat-soluble vitamins [61].

Bile contains water, bile acids, bilirubin, cholesterol, and electrolytes. Bile acids, synthesized from cholesterol, play a key role in the breakdown of fats, forming micelles that facilitate the transport and absorption of fatty acids and monoglycerides. Bilirubin, a breakdown product of hemoglobin, gives bile and, accordingly, feces its characteristic color [66].

The size of the bile ducts may vary depending on the age, sex, and general health of the patient. In healthy adults, the intrahepatic ducts are normally less than 2 mm in diameter and are usually not visible on ultrasound. When their diameter increases to 3 mm or more, which can occur in various diseases such as cholestasis or obstruction, the ducts become visible on ultrasound [17].

The right and left hepatic ducts are approximately 3-4 mm in diameter and merge to form the common hepatic duct, which is 4-6 mm in diameter. An increase in the diameter of the common hepatic duct may be observed with age or in diseases such as obstructive cholestasis. The common bile duct (choledoch) has a diameter of 4-6 mm in adults and up to 8 mm in the elderly. In patients after gallbladder removal, the diameter of the common bile duct may increase to 10 mm, which is not considered pathological [51].

Disorders of the sphincter can lead to diseases such as gallstones and cholecystitis and cause upper abdominal pain, highlighting the importance of the structure and function of this system [49].

The spleen is a lymphoid parenchymatous organ that performs immune surveillance and blood filtration functions. It is located in the upper left quadrant of the abdomen, in the left hypochondrium, between the ninth and eleventh ribs, at the level of the posterior diaphragm. The spleen is covered by a fibrous capsule that provides protection and support for the structure of the organ. However, the spleen is a soft organ, making it susceptible to injury from abdominal trauma [30]. The main functions of the spleen include the removal of old red blood cells, the storage and processing of iron, and the support of the immune system by producing antibodies and activating lymphocytes. During infections or inflammations, the spleen may enlarge, which is called splenomegaly [7].

The average weight of the spleen in an adult varies from 150 to 200 grams. In men, the organ is often larger than in women. The normal size of the spleen is 10-12 sm in length, 4-6 sm in width and 3-4 sm in thickness, although the exact figures may vary depending on age, body type and general health [41].

The structure of the spleen consists of white and red pulp [62]. The red pulp is a tissue consisting of a large number of venous sinuses and cells of the reticuloendothelial system. It acts as a blood filter, removing old or damaged red blood cells, platelets, and various pathogens. The red pulp also participates in iron metabolism, releasing it from destroyed red blood cells for subsequent use by the body [57].

The white pulp is a lymphoid tissue containing lymphocytes, macrophages, and other immune cells. It surrounds the arterial vessels of the spleen and forms lymph nodes, which play a key role in the body's immune responses. The white pulp serves as a site for lymphocyte activation and antibody production in response to invading antigens, making the spleen an important element of the immune system [62].

The spleen has an extensive vascular network, the main elements of which are the splenic artery and splenic vein. The splenic artery is a branch of the celiac trunk and supplies arterial blood to the spleen. Upon entering the organ, the artery divides into several segmental arteries, each of which supplies a separate segment of the spleen, which minimizes the risk of ischemia in the event of damage to one of the arteries [44].

Venous blood from the spleen is drained by the splenic vein, which joins with the superior mesenteric vein to form the hepatic portal vein. This process is of particular importance because the spleen filters the blood before it enters the liver, removing microorganisms and damaged cells. The venous sinuses, which form the basis of the red pulp, have a porous structure that facilitates the easy passage and filtration of blood through the organ [38].

Hematological function - the spleen acts as a filter for the blood, removing old, damaged, and abnormal cells. The spleen breaks down old red blood cells, platelets, and white blood cells, and also metabolizes hemoglobin and processes iron. This process is important for maintaining healthy blood composition and preventing excess accumulation of damaged cells in the bloodstream [31].

Immune function – the white pulp of the spleen is involved in immune responses by activating lymphocytes and macrophages, which are capable of capturing and destroying antigens and microorganisms. The lymphoid nodules of the white pulp function as immune centers, activating B and T lymphocytes and promoting the production of antibodies. The importance of the spleen in the immune system also lies in its ability to respond to infectious agents such as bacteria and viruses by stimulating the production of protective cells [55].

Metabolic function – The spleen plays a role in the metabolism of iron and other blood components. After the breakdown of red blood cells, iron is released from hemoglobin and transported to the bone marrow, where it is used to synthesize new blood cells. The spleen also plays a role in blood storage, storing platelets and other cells that can be released into the bloodstream when needed, such as during bleeding [65].

The size of the spleen varies depending on age, gender, and body type. In healthy adults, the spleen is 10-12sm long, 4-6 sm wide, and 3-4 sm thick. These parameters may change with age and body type: in men, the spleen is often larger than in women, and in people with an ectomorphic body type, the organ is usually smaller than in endomorphs [15].

In childhood, the spleen is smaller in size and gradually increases as the child grows, reaching adult values by the age of 15-18. In children aged 1 to 5 years, the length of the spleen is on average 6-7 sm, and by the age of 10 years - about 8-9 cm. These data are of great importance when assessing the condition of the spleen in children, since the size of the organ helps to identify possible pathologies, such as splenomegaly associated with infections or blood diseases [6].

The hepatobiliary system performs several key functions that support the body's metabolism and homeostasis.

The liver is responsible for the metabolism of proteins, fats, and carbohydrates, synthesizing important proteins such as albumin and clotting factors, which are needed to maintain blood pressure and protect against bleeding. In addition, the liver is involved in the regulation of blood glucose levels through glycogenolysis and gluconeogenesis, helping to maintain stable sugar levels, especially during periods of fasting [25].

The liver's functions also include detoxification and removal of harmful substances from the digestive system. Hepatocytes convert toxins and drugs, facilitating their elimination through the kidneys. This protective action of the liver is vital to preventing the accumulation of toxins and maintaining the health of other organs and tissues [23].

The pancreas, as mentioned, has a dual function. The endocrine part controls blood glucose levels, which is especially important in preventing metabolic disorders such as diabetes. The exocrine part, responsible for producing digestive enzymes, plays a crucial role in the digestion of food. These enzymes help break down carbohydrates, proteins, and fats, providing the body with essential nutrients [70].

The bile ducts transport bile to the intestines, where it participates in the breakdown and absorption of fats. Thanks to bile, the body is able to absorb fat-soluble vitamins, which is necessary to maintain healthy bones, the immune system, and cell membranes. Disturbances in the production or outflow of bile can lead to vitamin deficiency and deterioration of metabolic processes [39].

The spleen performs filtration and immune functions, removing old red blood cells and participating in the regulation of platelet and white blood cell levels. This organ activates lymphocytes, which play an important role in protecting against infections. In the presence of infection, the spleen actively participates in generating an immune response, making it important for maintaining the body's resistance to external factors [64].

Common liver pathologies include fatty liver disease, hepatitis, and cirrhosis. Fatty liver disease, caused by the accumulation of fats in hepatocytes, is increasingly common among patients with obesity and metabolic syndrome. Hepatitis, caused by infections or toxins, can lead to inflammation and damage to liver tissue, and if untreated, progress to cirrhosis, in which normal tissue is replaced by fibrous tissue [50].

The pancreas is susceptible to such pathologies as acute and chronic pancreatitis, as well as tumor processes. Acute pancreatitis is often caused by gallstones or alcohol abuse, which leads to inflammation of the pancreatic tissue and can cause serious complications such as necrosis. Chronic pancreatitis develops with prolonged exposure to harmful factors and is characterized by irreversible changes in the glandular tissue, which leads to disruption of digestive and endocrine functions [77].

Pancreatic cancers such as pancreatic cancer have a high mortality rate because their symptoms are often non-specific and diagnosis in the early stages is difficult. Pancreatic cancer is mostly detected at a late stage, making prevention and early detection critical in the fight against this disease [34].

The most common bile duct pathologies are cholecystitis, cholangitis, and cholelithiasis. Cholecystitis, an inflammation of the gallbladder, often occurs due to obstruction of the common bile duct by a stone, which causes pain and inflammation. Cholangitis, an infection of the bile ducts, can lead to serious complications if not diagnosed and treated promptly. Cholelithiasis, associated with the formation of stones in the gallbladder, is more common in obese people and can be complicated by inflammation and obstruction of the bile ducts [63].

These diseases tend to be widespread, especially among the elderly population and people with lipid metabolism disorders. Modern diagnostic methods, such as ultrasound, MRI and CT, allow for the detection of bile duct pathologies at early stages, which increases the chances of successful treatment [71].

The spleen is susceptible to pathologies such as splenomegaly, infarctions, cysts, and tumors. Splenomegaly (enlarged spleen) occurs in infections, anemia, autoimmune diseases, and liver cirrhosis. Enlarged spleen can cause mechanical and metabolic problems such as hypersplenism, which leads to destruction of blood cells and deficiency of white blood cells and platelets [58].

Splenic infarction occurs when the blood supply is reduced due to thrombosis or embolism and may be accompanied by severe pain and tissue necrosis. Cysts and tumors of the spleen are rare but require attention because they may become a source of complications or malignant growth [76].

Ultrasound diagnostics (US) is one of the leading methods of visualizing the hepatobiliary system due to its non-invasiveness, availability and safety for the patient. The method is based on the principle of reflection of high-frequency sound waves from tissues of different densities, which allows obtaining images of organs in real time. Ultrasound is widely used to examine the liver, pancreas, bile and hepatic ducts, and the spleen. The main advantages of ultrasound include the absence of radiation exposure, high resolution for soft tissues and the ability to assess the structure and size of organs, as well as to identify pathological changes such as tumors, cysts, inflammatory processes and stones [72].

Among visualization methods, ultrasound is highly sensitive in assessing changes in the echogenicity and structure of liver and pancreatic tissue, which allows for the detection of pathologies such as fatty hepatosis, cirrhosis, pancreatitis, and others. Ultrasound also allows for dynamic monitoring of the condition of patients with chronic diseases such as hepatitis and cholecystitis, making it an indispensable tool in gastroenterology [47].

When examining the hepatobiliary system, ultrasound allows not only to visualize the structure of the organs, but also to evaluate their blood supply using the Doppler mode. This method is especially useful in examining the hepatic and portal veins, as well as blood flow in the vessels of the pancreas, which allows identifying vascular pathologies and changes in blood supply caused by tumors or inflammatory processes [43].

The liver is one of the largest organs in the human body, weighing approximately 1.5 kg in men and slightly less in women. The size of the liver depends on age, gender, body type and ethnicity. Ultrasound allows us to measure the main parameters of the liver, such as length, width and thickness, as well as to assess its contours and echogenicity. On average, the length of the right lobe of the liver is from 13 to 15 sm, and the height of the right lobe is about 10-12 sm. The left lobe, in turn, has an average height of 7-10 sm and a thickness of 5-6 sm [11].

These parameters vary, and data on normal liver sizes collected by ethnicity have shown that individuals of Asian descent may have slightly smaller livers than individuals of European and African descent. In children, liver size varies with the stage of growth and development, with ultrasound used to establish liver size as normal for age and to detect abnormalities [36].

Ultrasound diagnostics allows measuring the size and echogenicity of the liver, which are key indicators for identifying pathologies. Normally, the size of the liver varies depending on the patient's gender, age, and body type. For the right lobe of the liver, the normal anteroposterior size is considered to be within 13–15 sm, and for the left lobe – 5–7 sm. The echogenicity of the liver is normally comparable to the echogenicity of the right kidney and slightly lower than the echogenicity of the pancreas [5].

Pathological changes such as fatty hepatosis are manifested by increased liver echogenicity, which is associated with lipid deposition in hepatocytes. In cirrhosis, heterogeneity of the structure and deformation of the liver contours are observed, as well as signs of portal hypertension, such as portal vein dilation and the presence of ascites. Ultrasound also allows for the detection of focal changes such as tumors, metastases, and cysts, which appear as hypoechoic, hyperechoic, or anechoic areas, depending on their composition and structure [48].

Ultrasound of the pancreas is a complex task due to its location behind the stomach and intestinal gases. Normally, the pancreas has uniform echogenicity and smooth, clear contours. The size of the gland varies, but the average values for the head are about 2.5–3.5 sm, for the body – 1.5–2.5 sm, and for the tail – up to 3 sm. The echogenicity of the pancreas is normally slightly higher than the echogenicity of the liver [16].

Pathological changes such as acute pancreatitis are manifested by an increase in the size of the gland and a decrease in its echogenicity, while in chronic pancreatitis, calcifications and thickening of the pancreatic duct are observed. Pancreatic tumors may appear as hypoechoic formations with fuzzy contours, which requires further examination using CT or MRI to clarify the diagnosis [33].

Bile ducts are divided into intrahepatic and extrahepatic. Extrahepatic bile ducts include the common hepatic duct and common bile duct, which are key in transporting bile from the liver to the duodenum. Normally, the diameter of the common hepatic duct is 4 to 6 mm in adults, while the size can increase with age, reaching 8 mm in the elderly. In clinical practice, an increase in diameter over 6-8 mm may indicate obstruction of the bile ducts or chronic inflammatory processes [8].

Intrahepatic ducts are usually less visible on ultrasound in normal conditions, as their diameter is 2 mm or less. However, in pathologies such as primary biliary cirrhosis or obstruction, intrahepatic ducts may dilate and become visible on ultrasound, which serves as an important diagnostic criterion. Dilation of intrahepatic ducts is often accompanied by an increase in the echogenicity of the liver parenchyma, indicating the development of cholestasis or other obstructive diseases [48].

Ultrasound examination of the bile and hepatic ducts includes an assessment of the diameter of the common bile duct, which normally does not exceed 6 mm in adults. An increase in the diameter of the duct may indicate its obstruction, which can be caused by stones, strictures, or tumors. The gallbladder is normally about 7–10 cm long and 3–4 cm wide, with anechoic contents [12].

The gallbladder, being a reservoir for bile, has normal dimensions of about 7-10 cm in length and 3-4 cm in width. Its shape is usually oval or pear-shaped, and the wall is up to 3 mm thick. An increase in wall thickness is often associated with inflammatory processes, such as cholecystitis. Normally, the contents of the gallbladder are anechoic (without internal echoes), but in the presence of stones or polyps, hyperechoic structures are observed that cast an acoustic shadow [16].

The incidence of gallstones varies by ethnicity and is approximately 10–20% in adults in Europe and North America, with higher incidence in women and increasing with age. Ultrasound can not only detect the presence of stones but also assess their number, size, and potential impact on biliary tract patency [73].

In pathologies such as cholecystitis, the gallbladder walls thicken and its contents become echogenic due to inflammation or infection. Gallstones are visible as hyperechoic structures with an acoustic shadow. It is also possible to detect polyps, which appear as hyperechoic formations without a shadow and require dynamic monitoring, as they can transform into tumors [27].

The spleen, when examined using ultrasound, normally has a uniform structure and smooth contours; its size in an adult is about 10–12 cm in length and 4–6 cm in width. The echogenicity of the spleen is comparable to the echogenicity of the liver, which allows us to evaluate its structure and identify abnormalities such as an increase in size (splenomegaly) in infectious diseases or portal hypertension [10].

On ultrasound examination, the size of the spleen may vary depending on the patient's gender and body type. An enlarged spleen (splenomegaly) is often a sign of portal hypertension, infectious diseases, or blood diseases. The spleen has a homogeneous echostructure, and any changes in its echogenicity may indicate pathological processes such as infarction or cysts [14].

Pathologies such as splenic infarctions appear as hypoechoic areas with fuzzy contours. In infectious processes, the structure of the spleen may become heterogeneous, which is accompanied by an increase in its size. Cysts and tumors are visible as anechoic or hypoechoic formations and require further examination using additional visualization methods [24].

Modern ultrasound machines allow detailed assessment of the echogenicity, size, volume and shape of the organs of the hepatobiliary system. To standardize the data, assessment systems are used on a scale from hypo- to hyperechogenicity, which allows doctors to compare the echogenicity of the organ under study with other structures, such as the liver and pancreas. Accurate measurement of the size and volume of organs is carried out using B-scan and 3D ultrasound modes, which allows the creation of three-dimensional images useful for determining anatomical features and pathologies [13].

The normal sizes of the hepatobiliary system organs and their ultrasound parameters vary significantly depending on age. In children, the liver and spleen are relatively smaller in size and increase with age, reaching values typical for adults by about 18-20 years. The liver in childhood is usually smaller in size, but its length and thickness increase faster during puberty [1].

With age, especially in patients over 60 years of age, some increase in the size of the liver and gallbladder may be observed, which is associated with age-related changes, including a decrease in tissue elasticity and the appearance of fat and collagen deposits in the structure of the organs. These age-related changes are important to consider when interpreting ultrasound results, since they can imitate the initial stages of fatty hepatosis or other pathologies [59].

According to statistical studies, ultrasound detects about 60-70% of all cases of fatty hepatosis in the early stages in adult patients, making it an important screening tool for preventive examinations. Among patients with chronic pancreatitis, ultrasound allows diagnosing structural changes in 80% of cases, including calcifications and duct dilation, indicating high sensitivity of the method for this pathology [22].

Studies also show that the incidence of cholelithiasis (gallstone disease) is about 20% among adults, with the risk increasing with age. The disease is twice as common in women as in men, which is due to hormonal factors. Ultrasound can detect stones in the gallbladder and bile ducts with a sensitivity of 95%, making it the method of choice for diagnosing this pathology [53].

These data emphasize the role of ultrasound in the diagnosis and monitoring of hepatobiliary diseases, as well as in the prediction and prevention of serious complications. Given the high accuracy and non-invasiveness of ultrasound, it is the first choice in the diagnostic process when there is a suspicion of hepatobiliary pathology.

Doppler sonography is used to evaluate blood flow in the vessels of the liver, pancreas, and spleen. It can detect vascular abnormalities such as portal vein thrombosis or disruption of blood supply due to tumors. Normally, blood flow velocity in the portal vein ranges from 13 to 18 cm/sec . Changes in blood flow, such as decreased velocity or the presence of reverse flow, may indicate portal hypertension, a condition often associated with liver cirrhosis. Doppler ultrasound can also evaluate the hepatic veins and arteries, detecting pathologies such as thrombosis or stenosis [37].

These blood flow parameters are particularly important in assessing the condition of patients with chronic liver diseases, since changes in the portal system may reflect the severity of the disease and prognosis. In particular, portal vein dilation greater than 13 mm and spleen enlargement often indicate the development of portal hypertension, which requires further monitoring and treatment adjustment [32].

Elastography is another innovative method that allows assessing the stiffness of liver tissue and can be used to diagnose fibrosis and cirrhosis, which significantly improves the capabilities of ultrasound diagnostics [74].

In addition, the use of contrast agents for ultrasound examination (contrast echography) allows for more precise visualization of vessels and tissue structures, which is especially useful in diagnosing tumors and assessing their blood supply. Contrast agents enhance tissue echogenicity, allowing for more precise determination of the size and structure of focal changes [78].

Conclusion. The hepatobiliary system is a complex anatomical and physiological complex that provides a wide range of vital functions of the body, including metabolism, digestion, hematopoiesis, detoxification and immune protection. The anatomical and ultrasound parameters of these organs vary depending on the age, gender, somatotype and ethnicity of the patient, which requires an individual approach to diagnosis.

Modern ultrasound examination methods, including B-mode, Dopplerography, elastography and contrast echography, are highly informative in assessing the morphological and functional features of the hepatobiliary system. Ultrasound allows us to identify a wide range of pathological changes - from diffuse diseases (fatty hepatosis, cirrhosis, pancreatitis) to focal lesions (tumors, cysts, stones), as well as assess the degree of portal hypertension and vascular disorders.

Given the high prevalence of hepatobiliary diseases, as well as the asymptomatic course of many pathologies in the early stages, ultrasound diagnostics remains the method of first choice in screening examinations and patient monitoring. The data obtained emphasize the need for a comprehensive multifactorial analysis of ultrasound parameters taking into account individual anatomical variations, which allows for increased diagnostic accuracy and timely prescription of adequate therapy.

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