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TOPOGRAPHIC-ANATOMICAL FEATURES OF FORMATION OF INTRAHEPATIC BILE DUCTS

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Topographic and anatomical features of intrahepatic bile ducts are an important aspect of surgery and gastroenterology. Therefore, we have studied options for the formation of the right, left and common hepatic ducts using the method of macroscopic preparation. It was determined that the common hepatic duct was formed from three ducts in 4 of 28 preparations, and from four ducts in 15. The right hepatic duct is formed by the segmental ducts of the right inferior, superior, and caudate lobes, and the left hepatic duct is formed by the segmental ducts of the left anterior, posterior, and quadrate lobes. In 28 preparations, 5 had no right hepatic duct, 3 had no right upper segmental duct, 1 had the right hepatic duct receiving branches from the left hepatic and accessory ducts, 3 had the ducts of the caudate lobe opening directly into the common hepatic duct, and 2 had accessory hepatic ducts.

Key words: intrahepatic bile ducts, method of macromicroscopic liver preparation, common hepatic duct, right and left hepatic ducts, segmental bile ducts.

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ТОПОГРАФО-АНАТОМІЧНІ ОСОБЛИВОСТІ ФОРМУВАННЯ ВНУТРІШНЬОПЕЧІНКОВОЇ ЖОВЧНОЇ ПРОТОКИ

Топографо-анатомічні особливості внутрішньопечінкових жовчних проток є важливим аспектом хірургії та гастроентерології. Тому нами були вивчені варіанти формування правої, лівої та загальної печінкових проток методом макроскопічного препарування. Встановлено, що з 28 препаратів загальна печінкова протока у 4 була утворена з трьох проток, у 15 – з чотирьох проток. Права печінкова протока утворена сегментарними протоками правою нижньою, верхньою та хвостатою часткою, а ліва печінкова протока – сегментарними протоками лівих передньої, задньої та квадратної часткою. З 28 препаратів у 5 була відсутня права печінкова протока, у 3-х – права верхня сегментарна протока. У 1-го – права печінкова протока отримувала гілки від лівого печінкової і додаткової проток, у 3-х – протоки хвостатої частки відкривалися безпосередньо в загальну печінкову протоку, у 2-х відзначалися додаткові печінкові протоки.

Ключові слова: внутрішньопечінкові жовчні протоки, метод макромікроскопічного препарування печінки, загальна печінкова протока, права і ліва печінкові протоки, сегментарні жовчні протоки.

Topographic and anatomical features of the intrahepatic bile ducts are an important aspect of surgery and gastroenterology. They determine the location, relationship with vessels and other structures of the liver. Intrahepatic bile ducts have a complex anatomical structure, which plays a key role in the functioning of the liver and biliary system [5].

Damage to the epithelium of the bile duct mucosa caused by autoimmune imbalance, viral or bacterial infection, toxic substances or developmental abnormalities leads to severe structural changes in the liver, causing high mortality [12].

Liver cancer represents the third leading cause of cancer-related death worldwide. Cholangiocarcinoma is the second most common type of liver cancer after hepatocellular carcinoma, accounting for 10–15 % of all primary liver malignancies. Both the incidence and mortality of cholangiocarcinoma have been steadily increasing during the last decade. Moreover, most cholangiocarcinoma's are diagnosed at an advanced stage, when therapeutic options are very limited [13].

Bile duct variations can have significant clinical implications, particularly in hepatobiliary surgery and interventional procedures. Variations in bile duct anatomy can increase the risk of bile duct injury during procedures like liver transplantation, cholecystectomy, and hepatic resections [4] Unrecognized anatomical variations may lead to bile leaks, strictures, or obstruction, requiring additional interventions [10]. Knowledge of bile duct variations is essential for donor selection and surgical planning to ensure successful graft function [6].

Pathology of the hepatobiliary system organs, which occur in humans in the form of gallstone disease and other diseases, occupy one of the first places in surgical interventions on the abdominal organs. A complete study of the biliary systems in mammals will help to find more effective methods of treatment and prevention [3].

Detailed mapping of biliary anatomy is an essential preoperative requirement for the proper choice of therapeutic approach as well as for reduction of iatrogenic biliary pathology which can negatively affect the hepatobiliary surgery outcome. Thorough understanding and preoperative knowledge of liver anatomy, including anatomical variants of vasculature and biliary system, is paramount [2]. Complications that arise when a surgeon is unaware of their existence can be severe, with adverse impact on patient outcomes. Historically, anatomical biliary variants were often underappreciated, and the prevalence is reported inconsistently in the literature [9].

The purpose of the study was to investigate the variants of formation of the right, left and common hepatic ducts using the method of macroscopic liver dissection.

Materials and methods. The work was performed at Azerbaijan Medical University Department of Human Anatomy and Medical Terminology. The object of the study was intrahepatic bile ducts taken from 28 cadavers of mature age.

The study used the macromicroscopic dissection method. Using binocular loupes (Heine HRP Set A (Germany), 3.5x, 4x, 6x magnification) we examined liver structures that were both visible and invisible to the naked eye but were considered too large for the microscope.

The macromicroscopic dissection method is used for a detailed study of anatomical structures, their topography and relationships with surrounding tissues. This method combines macroscopic and microscopic examination, allowing for the isolation and analysis of individual elements of the organ. It is used in morphological studies to identify features of the vascular network, biliary ducts and liver parenchyma [7].

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This method consists of several stages: 1. Fixation of the organ – the liver is fixed in formalin or another fixative solution to preserve the tissue structure. 2. Macroscopic dissection – layer-by-layer isolation of large anatomical structures such as vessels, bile ducts and liver segments is performed.

A binocular magnifying glass was used to examine the liver's atomic structures, visible and invisible to the naked eye but considered too large for the microscope. The cadavers' abdomens were opened along the midline, and once the liver was located, it was separated and isolated from surrounding structures (i.e., diaphragm, stomach, kidneys, and spleen).

The remaining peritoneum was separated from the hepatoduodenal ligament. The common bile duct was found and followed to the porta hepatis. The hepatic and segmental ducts were cleared of surrounding tissue. The liver tissue was separated with a special loop or forceps.

To create a background, black paper was placed under the ducts and photographs (camera model: Canon EOS R + RF 100mm f/2.8L Macro IS USM (Japan)) of the preparations were taken. The shooting was done at the limit of comparative magnification. The results of the study were recorded.

Results of the study and their discussion. The intrahepatic bile ducts include bile capillaries, lobular, segmental, right and left hepatic ducts.

In the preparations of the intrahepatic bile ducts we have studied, the right hepatic duct is formed by the right inferior and right superior segmental ducts. The right inferior segmental duct collects bile from the inferior segments of the right lobe of the liver with its anterior inferior and posterior inferior terminal branches. The right superior segmental duct is formed by the anterior superior and posterior superior branches of the right and quadrate lobes of the liver in the diaphragmatic surface area.

The left hepatic duct is formed by the anterior left and posterior left segmental ducts, which in turn are formed by the small ducts of the left lobe of the liver. The ducts of the quadrate lobe usually open into the left hepatic duct from the front, and the ducts of the caudate lobe from the back.

The common hepatic duct is formed dichotomously from the right and left hepatic ducts. In 14 of 28 preparations, it was formed from three ducts, and in 4 preparations from four ducts. In one case, the number of roots of the common hepatic duct reached six (Fig. 1).

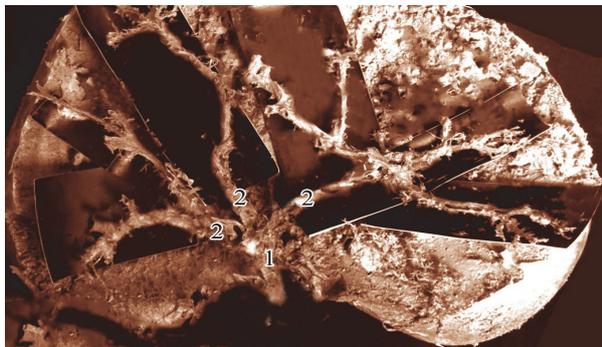


Fig. 1. Formation of the common hepatic duct. 1. Common hepatic duct. 2. Hepatic ducts.

The union of the ducts, regardless of their number, occurs both straight and at an angle of more than 90°. At the anterior edge of the hilum of the liver, the superior hepatic duct and the duct of the right lobe, which carry bile from the diaphragmatic segments, unite. The duct, which carries bile from the inferior segments of the right lobe, opens into the common trunk 1.2–1.5 cm below. In the scattered form of the biliary trees, three branches (from the left hepatic, right inferior and right superior ducts or from the left and right hepatic ducts and the duct of the caudate lobe) open into the common hepatic duct. We encountered the formation of the common hepatic duct from four ducts in two preparations. Thus, in one case, the anterior and posterior superior branches of the left hepatic, right inferior, right superior ducts open into the common hepatic duct, in other cases, the ducts of the left hepatic, right inferior, right superior and caudate lobes open into the common hepatic duct.

In most cases, the right hepatic duct is wide and collects bile from the segments of the right lobe, as well as from the quadrate and sometimes the caudate lobe. In our study, there was no right hepatic duct in 5 preparations. In this case, the right inferior and right superior ducts open independently into the common hepatic duct.

The number of branches of the right hepatic duct was usually 3–4. As a rule, these branches were the right superior and right inferior ducts, and the ducts of the caudate lobe. The right inferior duct, which receives bile from the segments of the right lobe of the liver, in most cases, the anterior and posterior branches of this duct are observed to be long.

The right superior hepatic duct is most often formed on the inferior surface of the diaphragmatic segments of the right lobe and on the superior surface of the quadrate lobe.

In 3 of 28 preparations, the right superior hepatic duct was absent. In one preparation, its anterior and posterior superior branches opened independently into the right hepatic duct. The number of main branches of the right superior hepatic duct, as a rule, did not exceed four or five.

The left hepatic duct is usually located at the anterior edge of the transverse fissure and above the left lobular branch of the portal vein. In our study, the diameter of this duct was larger than the diameter of the right hepatic duct in almost half of the preparations.

The left hepatic duct collects bile from all segments of the left lobe of the liver, most of the quadrate lobe. This is explained by the fact that the main trunk of the left hepatic duct is longer and its branches are relatively more numerous (on average from 5 to 7).

The largest root of the left hepatic duct is the left anterior duct, which collects bile from the anterior half of the left lobe. In some cases, we observed branches flowing into this duct from the upper parts of the left lobe. In 5 of 28 preparations, we were able to identify the left posterior duct, which collects bile from the dorsal region of the left lobe.

In most cases, three bile ducts from the quadrate lobe enter the left hepatic duct. Depending on the volume occupied by the liver parenchyma, the ducts of the quadrate lobe can be narrow or wide.

Summarizing the description of the architecture of the intrahepatic bile ducts, it can be noted that the right hepatic duct receives mainly branches of the right hepatic duct, and in rare cases, branches of the left hepatic and accessory ducts. Bile secretion from the parenchyma of the quadrate lobe is carried out by branches of both the right and left hepatic ducts. The left lobe of the liver secretes bile only into the left hepatic duct. The quadrate and caudate lobes can be divided into right and left halves based on the distribution of bile ducts in them.

In 3 out of 28 preparations, the ducts of the caudate lobe open directly into the common hepatic duct. In our study, in 2 preparations, additional hepatic ducts were identified that participate in the outflow of bile from the caudate lobes. Thus, in one preparation, the additional duct connected with the common hepatic duct, which collects bile from the visceral segments of the right lobe. In the other preparation, the additional duct drained bile from the parenchyma surrounding the gallbladder bed.

In 9 preparations, the branches of the right hepatic duct did not participate in the drainage of bile from the caudate lobe, and in 4 preparations the same picture was observed for the left hepatic duct. In 7 preparations, branches were observed that, flowing into one of the lobar ducts, went together with the blood vessels to the opposite trunk and collected bile from the opposite part of the lobe. In more than half of these cases, the inversion branches flowed into the right inferior or right hepatic duct.

In our material, in 8 cases the branches of the right hepatic duct did not participate in the drainage of bile from the caudate lobe, and in 2 cases the same picture was observed for the left hepatic duct.

In 18 preparations, bile from the quadrate lobe entered the left hepatic duct through three ducts, the branches of which were also found at the lower surface of the left lobe. According to the volume occupied in the liver parenchyma, the ducts of the quadrate lobe could be either narrow or wide.

In one preparation, the accessory duct flowed into the trunk of the common hepatic duct, collecting bile from the visceral segments of the right lobe. In another case, the accessory duct flowed into the right hepatic duct and diverted bile from the parenchyma surrounding the gallbladder bed. The inconsistency of the branching of the bile ducts of almost all bile drainage basins and the presence of inversion ducts indicate the need for individual planning of both external and internal bile secretion, especially if the block that caused mechanical jaundice is located intrahepatically.

We did not find a topographic correspondence between the intrahepatic branches of the portal vein and the branches of the right hepatic duct. Moreover, in 7 cases, a complete divergence of the branching of the right trunk of the portal vein and the right hepatic duct was detected.

Thus, the results of an anatomical study of 28 liver preparations show that there are various variants of the formation of bile ducts.

Li X. et al. (2022) used a computer-assisted surgery (CAS) system to create three-dimensional models of the biliary tract in 50 Chinese patients and investigated the variation in intrahepatic bile duct branching in the context of three-dimensional reconstruction of the biliary tract. The bile ducts were classified according to the union of the right posterior, right anterior sectoral, and left hepatic ducts, as well as the presence or absence of an additional common hepatic duct [8].

According to Bashir O, et al. (2025), the following variant of the anatomy of the intrahepatic bile ducts is quite common. Thus, in 15 % of cases, the right posterior sectoral duct opens into the left hepatic

duct. In 6 % of cases, the right anterior sectoral duct opens into the left hepatic duct. In 12 %, the right posterior sectoral duct opens into the right anterior sectoral duct. In 11 %, there is a “triple fusion” – the fusion of the right anterior sectoral duct, the right posterior sectoral duct and the left hepatic duct with the formation of a common hepatic duct. In 2 %, there is an additional hepatic duct [3].

El Hariri, M., et al. (2019) found that variations in bile duct anatomy can significantly impact hepatobiliary surgical techniques and patient outcomes. The study classified biliary variants based on the Huang classification and highlighted the importance of preoperative biliary mapping to reduce complications [4].

Uysal F. (2014) study examined the frequency of bile duct variations in over 1,000 patients using magnetic resonance cholangiopancreatography (MRCP). It found that trifurcation was the most common anatomical variation, followed by an aberrant right biliary duct draining into the common hepatic duct. The study emphasized the importance of recognizing these variations for liver transplantation and surgical planning [14].

A cadaveric study analyzed 50 liver specimens and identified accessory hepatic and cystic ducts in 4 % of cases. It also found abnormal low fusion of the cystic duct with the common hepatic duct in 2 % of cases. The study highlighted how these anomalies could contribute to postoperative complications if not properly identified [10].

Detailed mapping of biliary anatomy is an essential preoperative requirement for the proper choice of therapeutic approach as well as for reduction of iatrogenic biliary pathology which can negatively affect the hepatobiliary surgery outcome. Thorough understanding and preoperative knowledge of liver anatomy, including anatomical variants of vasculature and biliary system, is paramount [2].

The obtained data on the variation of intrahepatic bile duct anatomy may be useful during procedures such as liver transplantation, cholecystectomy and liver resection. Data on the topographic-anatomical variations of intrahepatic bile ducts are necessary for donor selection and surgical planning to ensure successful graft function.

Conclusions

1. The common hepatic duct was formed from three ducts in 4 of 28 preparations, and from four ducts in 15. In one case, the left hepatic, right inferior, right superior ducts opened into the common hepatic duct, and in another case, the left hepatic, right inferior, right superior, and caudate ducts opened into the common hepatic duct. In one preparation, the number of roots of the common hepatic duct reached six.

2. The right hepatic duct was formed from the inferior and superior segmental ducts and caudate ducts collecting bile from the right lobe of the liver, and the left hepatic duct from the anterior and posterior segmental ducts of the left lobe of the liver, and the quadrate segmental ducts. In five preparations, the right hepatic duct was absent. In this case, the right inferior and right superior ducts opened independently into the common hepatic duct.

3. In 3 of 28 preparations, there was no right superior hepatic duct. In this case, its anterior and posterior superior branches opened independently into the right hepatic duct. The number of main branches of the right superior hepatic duct, as a rule, did not exceed four or five.

4. In 1 of 28 preparations, the right hepatic duct receives branches from the left hepatic and accessory ducts.

5. In 3 of 28 preparations, the ducts of the caudate lobe open directly into the common hepatic duct. In 2 preparations, in addition to the accessory ducts, auxiliary hepatic ducts were identified, which participate in the outflow of bile.

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STUDY OF HEMATOLOGICAL PARAMETERS OF RABBIT OFFSPRING SUBJECTED TO PRENATAL HYPOKINESIA

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Changes in the blood parameters of newborn rabbit offspring whose prenatal development occurred under conditions of hypokinesia at various stages of pregnancy were explored. The changes in blood parameters were also observed to affect the viability of the offspring, depending on the pregnancy stage affected by hypokinesia. It was found that the embryonic stage is the most sensitive period, as the number of offspring born during this stage was lower compared to the control group. Based on our experiments, it can be stated that the most resilient stage in terms of offspring number is the fetal stage of pregnancy. The reproductive performance of female rabbits exposed to hypokinesia during this stage was similar to that of the control group and was approximately 90 %. It should be noted that the reduced viability of the newborn offspring is associated with profound changes in the vascular system of the “mother-fetus” system. Unlike pregnant rabbits that underwent gestation under normal conditions, newborns whose prenatal development occurred under hypokinetic conditions at different stages of pregnancy showed alterations in leukocyte formula parameters, platelet concentration, and erythrocyte sedimentation rate. The results of our research indicate that the investigation of erythrocyte and leukocyte formulas during pregnancy may be useful for implementing early preventive measures to mitigate the adverse effects of hypokinesia. These findings provide an important scientific foundation for studying the impact of restricted movement – hypokinesia – on reproductive health in space and for preserving the reproductive functions of animals and humans during future space missions.

Key words: hypokinesia, embryo, pre-fetal growth, prenatal period.

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ДОСЛІДЖЕННЯ ГЕМАТОЛОГІЧНИХ ПОКАЗНИКІВ ПОТОМСТВА КРОЛИКІВ З ДОСВІДОМ ПРЕНАТАЛЬНОЇ ГІПОКІНЕЗІЇ

Досліджено зміни показників крові новонародженого потомства кроликів, пренатальний розвиток яких відбувався в умовах гіпокінезії на різних етапах вагітності. Відзначено, що зміни в параметрах крові також впливають на життєздатність потомства залежно від стадії вагітності, яка зазнала гіпокінезії. Встановлено, що ембріональний етап є найбільш чутливим періодом, оскільки кількість народженого потомства в цей період була нижчою порівняно з контрольною групою. На підставі проведених експериментів можна стверджувати, що найбільш стійким з точки зору кількості потомства є фетальний етап вагітності. Репродуктивна здатність самок кроликів, які зазнали гіпокінезії в цей період, була порівнянна з контрольною групою і становила близько 90 %. Слід зазначити, що зниження життєздатності новонародженого потомства пов'язане з глибокими змінами в судинній системі «мати-плід». На відміну від вагітних кролиць, які виношували потомство в нормальних умовах, новонароджені, пренатальний розвиток яких проходив в гіпокінетичних умовах на різних етапах вагітності, демонстрували зміни в параметрах лейкоцитарної формули, концентрації тромбоцитів і швидкості осідання еритроцитів. Результати нашого дослідження свідчать про те, що вивчення еритроцитарної та лейкоцитарної формул під час вагітності може бути корисним для реалізації ранніх профілактичних заходів з метою пом'якшення несприятливих наслідків гіпокінезії. Ці дані є важливою науковою основою для вивчення впливу обмеженої рухливості – гіпокінезії – на репродуктивне здоров'я в космосі та збереження репродуктивних функцій тварин і людини під час майбутніх космічних місій.

Ключові слова: гіпокінезія, ембріон, префетальний розвиток, пренатальний період.

Hypokinesia is characterized by a prolonged and considerable reduction in the range of movement [13]. From both a biological and medical perspective, the issue of mobility is particularly important during pregnancy. Summarizing the results of studies on the responses of the nervous and muscular systems, it should be noted that under conditions of experimental hypokinesia, distinct and polymorphic neurological