During any surgery, in addition to pathology-related factors, it is necessary to evaluate the individual features of the anatomy of a particular area or complex of organs. The relevance of such data is confirmed by the results of numerous studies that show that half of patients are characterized by certain anatomical variants, including the location of the arteries and biliary tract. The purpose of the work is to establish the peculiarities of the morphometric parameters of the components of the hepatic-duodenal ligament. The study was based on 50 preparations of fetus corpses (4 to 10 months) and 10 newborns without external signs of anatomical abnormalities or congenital malformations. Adequate anatomical methods were used during the study: macropreparation, injection of blood vessels, making topographic anatomical sections, morphometry. Statistical analysis of the obtained data was performed using the licensed program RStudio. During the perinatal period, the length of the hepatic-duodenal ligament was found to increase from 5.224±0.572 mm in fetuses for 4 months to 32.12±1.77 mm in newborns. The chart of change of the average values of its length by months of prenatal development indicates uneven increase of organometric parameters. From 4 to 5 months observed a significant increase in the length of the hepatic-duodenal ligament, while from 5 to 7 months of development observed a period of relative slowdown of its length, and from 5 to 6 months of development even a relative decrease in length. The period from 7 to 10 months determines the period of accelerated growth of ligament. The indices of the width of the hepatic-duodenal ligament in the perinatal period increased from 3.292±0.227 mm in fetus of 4 months to 21.25±0.938 mm in newborns. The width increases are not uniform. The periods of accelerated development (4-5 months and 9 months - newborns) and the period of slow development (5-8 months) were observed. It was proved that there are periods of accelerated and slow development, in which during periods of intensive development, organometric indicators always differed significantly, were smaller than the previous ones and outweighed the following ones respectively (4-5 months and 7-9 months, p<0.05). Regarding the periods of slow development, the organometric indicators in these periods did not differ significantly (p>0.05). Therefore, analyzing the dynamics of changes in the morphometric parameters of the components of the hepatic-duodenal ligament, revealed periods of their accelerated and slow growth.

**Keywords:** hepatoduodenal ligament, fetus, anatomy, human.

**Introduction**

Hepatic-duodenal ligament, portal hepatic vein and gallbladder are target structures during laparoscopic cholecystectomy - one of the most common surgical interventions. This manipulation is for the purpose of treating gallstone disease, which, although a benign disease, is potentially dangerous to the patient. As with any surgical manipulation, cholecystectomy is at risk for complications and errors for the surgeon. Considering the importance of the communication structures: biliary tract, portal hepatic vein, hepatic arteries, etc., any damage to them is dangerous to the life of the patient [21-23]. That is why, along with surgical skills, knowledge of variants and features of the topography of structures of the hepatic-duodenal ligament is equally important for the favorable course of surgery. The ductal system of the liver, gallbladder and pancreas develop from the endodermal diverticula of the duodenum, which are
immersed in the transverse septum, which promotes the formation of a ligamentous apparatus - the small omentum and hepatic-duodenal ligament [24, 25]. Further growth and rotation of the duodenum lead to displacement of the rudiments of the pancreas and extrhepatic bile ducts more dorsally than the duodenum [1-6].

The gallbladder and bladder duct develop from the vesical diverticulum. Certain features of its development lead to the formation of certain variants of the structure. By this term we can mean the doubling of the gallbladder, the septum of the bladder, the bladder deeply immersed in the parenchyma of the liver, the gallbladder with mesentery and the left-sided position of the gallbladder. It should be noted that most of these anatomical features (except for the deep position of the bladder) do not present complications for the surgeon during cholecystectomy [7-12].

The purpose of the study was to determine the peculiarities of the morphometric parameters of the components of the hepatic-duodenal ligament of fetuses and newborns.

Materials and methods

The study was based on 50 preparations of corpses of fetus (4 to 10 months) and 10 newborns without external signs of anatomical abnormalities or congenital malformations. Adequate anatomical methods were used during the study: macropreparation, injection of blood vessels, making topographic anatomical sections, morphometry.

The work was performed in compliance with the main provisions of the Declaration of the World Medical Association on the ethical principles of conducting scientific and medical research with human participation (1964-2000) and the order of the Ministry of Health of Ukraine No. 690 of 23.09.2009 and is a fragment of a comprehensive planned initiative scientific research work of department anatomy of human named after M.G. Turkevych, anatomy, topographic anatomy and operative surgery of the Higher Medical Institute of Ukraine "Bukovinian State Medical University": "Features of morphogenesis and topography of organs and systems in prenatal and postnatal ontogeny periods" (State registration no. 0115U002769).

Statistical analysis of the obtained data was performed using the licensed program RStudio. The null hypothesis was tested that the samples were taken from one distribution or from distributions with the same median:

\[ H_0: \text{each group has the same distribution}\]
\[ H_1: \text{each group does not have the same distribution}.\]

The nature of the distributions was estimated for each of the variations obtained, the average for each trait being studied, the standard deviation, the percentile span of the indicators. Used Student’s t test, nonparametric Kruskal-Wallis test (answers the question whether there are differences between group distributions, but does not specify which groups are different), Conover-Iman test for comparison of stochastic dominance and results between different pairwise comparisons after test for stochastic dominance among groups. Statistically significant values were considered to be \( p < 0.05. \)

Results

Analyzing the organometric parameters of the hepatic-duodenal ligament by constructing a box diagram (Fig. 1), it can be seen that the difference between the medians of the samples (horizontal line in the box) is statistically significant. The Kruskal-Wallis test performed the following results: since \( p < 0.05, \) the difference between the medians of the groups is statistically significant. Using the Conover-Iman test, when comparing the morphometric parameters of the length of the hepatic to duodenal ligament of fruits of different age groups and newborns, revealed certain features of their dynamics. The length of the hepatic-duodenal ligament of the fetus of 4 months significantly shorter than in fetus of 5 months \( (p < 0.05). \) However, this parameter is not significantly different from such fruits for 6 months \( (p > 0.05), \) the latter, in turn, is significantly smaller than the length of the hepatic-duodenal ligament of the fetus for 5 months. Further, from the 6th to the 9th month of development, the morphometric indices differ significantly with each other, and the index of the length of the hepatic-duodenal ligament of each subsequent month significantly exceeds that of the previous month. Median difference for couple: “10 months” - “newborns” are not statistically significant \( (p > 0.05), \) that is, the length of the hepatic-duodenal ligament of the fetus is 10 months and newborns were not significantly different, although they were by far the highest among all study groups.

Descriptive statistics of the length of the hepatic-duodenal ligament during the perinatal ontogeny period are presented in Table 1. The graph of the mean values of hepatic-duodenal ligament by age group (Fig. 2) of the perinatal period indicates the intensity of changes in the parameters of hepatic-duodenal ligament during the perinatal ontogeny period. Column diagram for the group of medium hepatic-duodenal ligament widths looks like (Fig. 3).

Analyzing the morphometric parameters of the width of the hepatic-duodenal ligament by constructing a box
diagram (see Fig. 3), it can be seen that the difference between the medians of the samples (horizontal line in the box) is statistically significant. The Kruskal-Wallis test performed the following results: since \( p<0.05 \), the difference between the medians of the groups is statistically significant. Using the Conover-Iman test, when comparing the organometric parameters of the width of the hepatic-duodenal ligament of fetus of different age groups and newborns revealed certain peculiarities of their dynamics. Width of hepatic-duodenal ligament of fetus 4 months significantly less than in fetus of all subsequent age groups (5 months - newborns) \( (p<0.05) \). However, this parameter is not significantly different from such fetus for 5 months and 6 months \( (p>0.05) \), the latter in turn significantly smaller than the width of the hepatic-duodenal ligament of the fetus for 7 months - newborns. In the following, the parameters of the width of the hepatic-duodenal ligament from fetus 7 months to newborns significantly outweigh those of the previous month and significantly less than the parameters of the following months.

Descriptive statistics of the width of the hepatic-duodenal ligament during the perinatal ontogeny period are presented in Table 2.

The graph of mean hepatic-duodenal ligament lengths by age group (Fig. 4) of the perinatal period indicates the intensity of change in hepatic-duodenal ligament width during the perinatal period.

**Discussion**

Comparing the graphs of the average values of the length and width of the hepatic-duodenal ligament at each of the stages of the perinatal period, it is worth noting that some processes of increasing organometric parameters are not synchronous.

The graph of average values of the length of the hepatic-duodenal ligament by age groups of the perinatal period indicates the presence of two periods of accelerated development (4-5 months and 7-9 months) and a period of slow development (5-7 months). Regarding the width of the ligament, we found that there were two periods of accelerated development (4-5 months and 9 months - newborns) and a period of slow development (5-8 months).
It is worth noting that at some stage of development (6 months), the length of the hepatic-duodenal ligament is even slightly reduced, which can probably be associated with an increase in the adjacent organs - the liver and the duodenum in this period [13-20].

The presence of periods of accelerated and delayed development is confirmed by the validity of the differences in indicators of width and length of hepatic-duodenal ligament. The period of slow increase in the ligament length is 5-7 months, coincides with periods of no significant difference between organometric parameters (p>0.05). At the same time, the periods of accelerated growth coincide with the periods of significant difference in the morphometric parameters of the ligament (4-5 months and 7-9 months, p<0.05). A similar situation was observed with periods of intensive and slow growth of the link width. For 4-5 months we observe a period of accelerated increase in the width of the hepatic-duodenal ligament at the same time, the morphometric parameters significantly increase and differ (p<0.05). While in the period of slow development (5-6 months), the morphometric parameters of the ligament width do not differ (p>0.05).

Conclusions
1. During the perinatal period, the length of the hepatic-duodenal ligament increases from $5.224 \pm 0.572$ mm in fetuses for 4 months to $32.12 \pm 1.77$ mm in newborns. The chart of change of the average values of its length by months of prenatal development indicates uneven increase of organometric parameters. From 4 to 5 months observed a significant increase in the length of the hepatic-duodenal ligament, while from 5 to 7 months of development observed a period of relative slow down of its length, and from 5 to 6 months of development even a relative decrease in length. The period from 7 to 10 months determines the period of accelerated growth of ligament.

2. The indices of the width of the hepatic-duodenal ligament in the perinatal period increase from $3.292 \pm 0.227$ mm in the fetus in 4 months to $21.25 \pm 0.93$ mm in newborns. The width increases are not uniform. The periods of accelerated development (4-5 months and 9 months - newborns) and the period of slow development (5-8 months) were observed.

3. It is proved that there are periods of accelerated and delayed development, according to which, during periods of intensive development, organometric indicators always differed significantly, were smaller than the previous ones and outweighed the following ones respectively (4-5 months and 7-9 months, p<0.05). Regarding the periods of slow development, the organometric indicators in these periods did not differ significantly (p>0.05).

References
[1] Akhtemiychuk, Yu. T., Khmara, T. V., & Proniaiev, D. V. (2008). Variant of the abdominal cavity organ’s anatomy. Clinical Anatomy and Operative Surgery, 7(3), 81-82.
[2] Akhtemiychuk, Yu. T., Slobodyan, O. M., Khmara, T. V., Zavolovyich, A. Y., Olynyk, I. Yu., Proniyayev, D. V., ..., Kryvetskiy, V. V. (2011). Essays on Perinatal Anatomy. Chernivtsi: BSMU.
[3] Choi, J. U., Hwang, S., Ahn, C. S., Moon, D. B., Ha, T. Y., Kim, K. H., ..., Lee, S. G. (2019). Prolonged occlusion of the hepatoduodenal ligament to reduce risk of bleeding and tumor spread during recipient hepatectomy for living donor liver transplantation. Annals of Hepato-Biliary-Pancreatic Surgery, 23(1), 61-64. doi: 10.14701/ahbps.2019.23.1.61
[4] Corazziari, E., Cicala, M., Habib, F. I., Scopinaro, F., Fiocca, F., Pallotta, N., ..., Torsoli, A. (1994). Hepatoduodenal bile transit in cholecystectomized subjects. Digestive Diseases and Sciences, 39(9), 1985-1993. doi: 10.1007/bf02088136
[5] De Roo, A. C., Siddiqui, S., & Mychaliska, G. B. (2017). Hepatoduodenal ligament teratoma with immature elements. Pediatric Surgery International, 33(9), 1023-1026. doi: 10.1007/s00383-017-4123-2
[6] Gadzijev, E. M. (2002). Surgical anatomy of hepatoduodenal ligament and hepatic hilus. Journal of Hepato-Biliary Pancreatic Surgery, 9(5), 531-533. doi: 10.1007/s005340200068
[7] Garg, S., Hemanth, K. K., Sahni, D., Aggarwal, A., Gupta, T., & Yadav, T. D. (2015). Rare ringlike hepatic arterial anastomoses in the hepatoduodenal ligament. Journal of Vascular and Interventional Radiology: JVIR, 26(6), 923-925. doi: 10.1016/j.jvir.2014.12.611
[8] Gerrard, A. D., Lunevicius, R., & Heavey, N. (2019). Traumatic bruising of the hepatoduodenal ligament can conceal a catastrophic injury to the hepatic artery. BMJ Case Reports CP, 12(9), e230706. doi: 10.1136/bcr-2019-230706
[9] Gundapaneni, S., Dhua, A. K., Jain, V., Jana, M., Agarwala, S., & Bhathagav, Y. (2018). Teratoma in the hepatoduodenal ligament. Journal of Indian Association of Pediatric Surgeons, 23(4), 229-231. doi: 10.4103/japs.JIAPS_36_18
[10] Hayashi, H., Takamura, H., Higashi, Y., Shoji, M., Nakamura, S. I., Tajima, H., ..., Kakinoki, K. (2014). Relationship Between Midgut Malrotation and Anatomy of the Hepatoduodenal Ligament: A Rare Anatomical Variation in a Deceased Donor. In Transplantation Proceedings, 46(4), 1087-1089. doi: 10.1016/transpro.2013.09.050
[11] Inoue, Y., Salaia, A., & Takahashi, Y. (2018). A Novel Classification and Staged Approach for Dissection Along the Celiac and Hepatic Artery During Pancreatocoduodenectomy. World Journal of Surgery, 42(9), 2933-2967. doi: 10.1007/s00268-018-5450-9
[12] Jeismann, V. B., Dumarco, R. B., di Loreto, C., Barbuti, R. C., & Bhatnagar, V. (2018). Teratoma in the hepatoduodenal ligament. World Journal of Gastrointestinal Surgery, 6(5), 80-83. doi: 10.4240/wjgs.v6.i5.80
[13] Kaneoka, Y., Maeda, A., & Isogai, M. (2015). En bloc resection of the hepatoduodenal ligament for advanced biliary malignancy. Journal of Gastrointestinal Surgery, 19(4), 709-714. doi: 10.1007/s11605-014-2731-x
[14] Kaneoka, Y., Yamauchi, A., Isogai, M., Harada, T., & Suzuki, M. (2003). Hepatoduodenal ligament invasion by gallbladder carcinoma: histologic patterns and surgical recommendation. World Journal of Surgery, 27(3), 260-265. doi: 10.1007/s00268-002-6702-0
[15] Kayaalp, C., Tolan, K., & Yilmaz, S. (2016). Hepatoduodenal
Органометрические параметры печеночно-двенадцатиперстной связки в перинатальном периоде
Юзько Р.В., Слободя А.М.
При проведении любой оперативной вмешательной, сколь бы значительными не были изученные в литературе данные, необходимо учитывать индивидуальные особенности анатомии младенца. Многообразие вариантов анатомии печёночно-двенадцатиперстной связки не позволяет применить в оперативной хирургии стандартные подходы. В зависимости от целей операции и особенностей анатомии, оценивается исходное состояние пациента для принятия окончательного решения о возможности выполнения операции.

Ключевые слова: печеночно-двенадцатиперстная связка, плод, анатомия, людина.
лицензированной программы RStudio. Установлено, что в течение перинатального периода длина печечно-двенадцатиперстной связки увеличивается от 5,224±0,572 мм у плодов 4 мес. до 32,12±1,77 мм у новорожденных. График изменения средних значений ее длины по месяцам внутриутробного развития указывает на неравномерное увеличение органометрических параметров. Так, с 4 по 5 мес. наблюдалось существенное увеличение длины печечно-двенадцатиперстной связки, в то время как с 5 по 7 месяц развития наблюдали период относительного замедления увеличения ее длины, а в период с 5 по 6 месяц внутриутробного развития даже относительное уменьшение длины. В период с 7 по 10 месяц определяется период ускоренного роста связки. Показатели ширины печечно-двенадцатиперстной связки в перинатальном периоде растут с 3,292±0,227 мм у плодов 4 мес. до 21,25±0,938 мм у новорожденных. Увеличение ширины происходит не равномерно. Наблюдались периоды ускоренного развития (4-5 мес. и 9 мес. - новорожденные) и период замедленного развития (5-8 мес.). Было доказано наличие периодов ускоренного и замедленного развития, по которым в периоды интенсивного развития органометрические показатели всегда достоверно отличались, были меньше предыдущих и преобладали над последующими, соответственно (4-5 мес. и 7-9 мес., р<0,05). Относительно периодов замедленного развития, то органометрические показатели в данные периоды достоверно не отличались (р>0,05). Итак, анализируя динамику изменений морфометрических параметров компонентов печечно-двенадцатиперстной связи, выявлены периоды их ускоренного и замедленного роста.

Ключевые слова: печечно-двенадцатиперстная связка, плод, анатомия, человек.