УДК 616.149:611.149]-073.756.8
https://doi.org/10.20538/1682-0363-2021-4-49-55

Features of morphometric parameters of vessels in the human portal venous system identified by multislice computed tomography

Russkikh A.N., Shabokha A.D., Tyumentsev N.V., Derevtsova S.N.

V.F. Voino-Yasenetsky Krasnoyarsk State Medical University
1, Partizana Zheleznyaka Str., Krasnoyarsk, 660022, Russian Federation

ABSTRACT

The aim of this study was to identify the morphometric features of the human portal venous system by means of multislice computed tomography (MSCT).

Materials and methods. A contrast X-ray study of the portal vein was carried out in 53 men who were treated in the surgical departments of the Krasnoyarsk Regional Hospital No. 1. The average age of the patients was 54.9 ± 1.7 years (36–71 years). Measurements were performed on 3D models of the vascular bed in the portal venous system (GE Advantage Workstation and Siemens singo.via workstations). Branching patterns, length, diameter, angle of the portal vein formation relative to the midline of the human body, and angles of formation of the vessels forming the portal vein in the frontal plane were evaluated.

Results. Variations in the morphometric parameters of the intrahepatic vessels of the portal vein are obvious, although the branching patterns are not diverse and are reduced to one type – the magistral pattern (according to V.N. Shevkunenko). The veins that form the portal vein are represented by three systems, each of which has a stem and tributaries that differ in branching patterns and other morphological characteristics.

Conclusion. The findings of the study made it possible to supplement the scientific materials regarding branching patterns and morphological characteristics of the portal vein and its tributaries as well as to use the morphometric characteristics of the superior and inferior mesenteric and splenic veins to resolve the issues of surgical intervention on the abdominal organs.

Key words: portal vein, 3D modeling, branching pattern, superior mesenteric vein, inferior mesenteric vein, splenic vein.

Conflict of interest. The authors declare the absence of obvious or potential conflict of interest related to the publication of this article.

Source of financing. The authors state that they received no funding for the study.

Conformity with the principles of ethics. All patients signed an informed consent to participate in the study. The study was approved by the local Ethics Committee at V.F. Voino-Yasenetsky Krasnoyarsk State Medical University (Protocol No. 84/2018 of 06.06.2018).

For citation: Russkikh A.N., Shabokha A.D., Tyumentsev N.V., Derevtsova S.N. Features of morphometric parameters of vessels in the human portal venous system identified by multislice computed tomography. *Bulletin of Siberian Medicine.* 2021; 20 (4): 49–55. https://doi.org/10.20538/1682-0363-2021-4-49-55.

✉ *Shabokha Anna D.,* e-mail: tat_yak@mail.ru

Особенности морфометрических показателей сосудов воротной системы человека, выявленные посредством мультиспиральной компьютерной томографии

Русских А.Н., Шабоха А.Д., Тюменцев Н.В., Деревцова С.Н.

Красноярский государственный медицинский университет (КрасГМУ) им. проф. В.Ф. Войно-Ясенецкого Россия, 660022, г. Красноярск, ул. Партизана Железняка, 1

РЕЗЮМЕ

Цель – выявление морфометрических особенностей воротной системы человека посредством мультиспиральной компьютерной томографии.

Материалы и методы. Для решения поставленной задачи проведено рентгенконтрастное исследование воротной вены 53 мужчинам, проходившим лечение в хирургических отделениях Красноярской краевой больницы № 1. Средний возраст составил 54,9 ± 1,7 лет (36–71 год). Измерения проводились на мультипланарных реконструкциях сосудистого русла воротной системы (рабочие станции GE Advantage Workstation, Siemens singo.via). Оценивались типы ветвления, длина, диаметр, угол образования воротной вены относительно срединной линии тела человека и углы образования сосудов, образующих воротную вену во фронтальной плоскости.

Результаты. Вариации морфометрических параметров внутрипеченочных сосудов воротной вены очевидны, хотя варианты ветвления неразнообразны и сводятся к одному типу – магистральному (по В.Н. Шевкуненко). Вены, образующие воротную вену, представлены тремя бассейнами, в каждом из которых имеются ствол и притоки, отличающиеся типами ветвления и другими морфологическими характеристиками.

Заключение. Исследование позволило дополнить научные материалы относительно типов ветвления и морфологических параметров воротной вены и ее ветвей, использовать морфометрические характеристики верхней, нижней брыжеечных и селезеночной вен для решения вопросов хирургического вмешательства на органах брюшной полости.

Ключевые слова: воротная вена, 3D-моделирование, тип ветвления, верхняя брыжеечная вена, нижняя брыжеечная вена, селезеночная вена.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Источник финансирования. Авторы заявляют об отсутствии финансирования при проведении исследования.

Соответствие принципам этики. Все пациенты подписали информированное согласие на участие в исследовании. Исследование одобрено локальным этическим комитетом КрасГМУ (протокол № 84/2018 от 06.06.2018).

Для цитирования: Русских А.Н., Шабоха А.Д., Тюменцев Н.В., Деревцова С.Н. Особенности морфометрических показателей сосудов воротной системы человека, выявленные посредством мультиспиральной компьютерной томографии. *Бюллетень сибирской медицины.* 2021; 20 (4): 49–55. https://doi.org/10.20538/1682-0363-2021-4-49-55.

INTRODUCTION

Variability of the human portal venous system is beyond doubt [1–5]. Features of interposition, branching of veins included in this system, and its stereometric and linear characteristics define the development, course, and methods of surgical intervention for several surgical diseases, which eventually determines the outcome of surgical pathology [6–8]. According to leading gastrointestinal surgeons, enhancement of diagnosis of the structural features in the portal venous system will allow to answer many questions about the therapeutic and diagnostic strategy in the preoperative period [9–12].

Radiographic testing of vessels, organs, and entire systems in various areas of medical practice shows good diagnostic results [13, 14]. A study carried out on a stationary X-ray machine in order to identify the features of rectal vessels of the portal venous system proved high information capacity of the method and allowed to find out postmortem characteristics, such as morphometry, spatial location, and vein branching [15–18].

Variant anatomy of major vessels of the portal venous system has been studied by a number of authors [19–22]. In 2018, I.V. Gaivoronsky et al. presented the main results characterizing variants of portal vein trunk formation and quantitative measurements of the vein length, diameter, and roots, showing a wide range of morphometric characteristics. The results obtained by multislice computed tomography (MSCT) of the abdominal cavity were defined as markers that allowed for planning an optimal surgical strategy and reducing postoperative complications on the part of the mesenteric and portal vein system in acute extensive portal vein or superior mesenteric vein thrombosis [6].

However, the study results can be applied only to operations on abdominal organs, in which the major vessels of the portal venous system are involved. According to A.V. Kolsanov et al. (2017), for a comprehensive study of the portal venous system of living people, it is eligible and competent to use contrast computed tomography with bolus tracking, which is one of the most precise methods to estimate morphometric features of vascular formations. Such a technique is the best for studying variant angioanatomy with visualization of vessels with a diameter of 1 mm and more, which allows to use this method not only in choosing the surgical strategy to treat portal hypertension, but also in all types of liver and pancreatic resection, liver transplantation etc. [9].

The aim of the study was to identify the morphological features of the human portal venous system.

MATERIALS AND METHODS

A contrast X-ray study was carried out on 53 men who were treated in the surgical departments of the Krasnoyarsk Regional Hospital No. 1. The inclusion criterion: patients with surgical diseases of the abdominal organs without circulatory disorders. The average age of the patients was 54.9 ± 1.7 years (36–71 years). All patients signed an informed consent to participate in the study. The study was approved by the local Ethics Committee at V.F. Voino-Yasenetsky Krasnoyarsk State Medical University (Protocol No. 84/2018 of 06.06.2018).

The measurements were performed on 3D reconstructions of the vascular bed of the portal venous system (GE Advantage Workstation and Siemens singo.via working stations) on the basis of MSCT scans of the abdominal cavity using bolus contrasting with Ultravist-370 (Bayer Pharma AG, Germany). The volume of the used contrast medium was 100 ml, the injection rate was 4 ml per second, and the average radiation exposure was 11.3 mSv.

The contrast X-Ray study is applicable to the study of variants of portal venous system formation and their morphometric patterns, as well as branching patterns at different levels of structural organization using classifications by the T. Nakamura (type A – classical anatomy, type B – portal trifurcation, type C – intra-; type D – extrahepatic branching of the anterior branch, and type E – absence of the anterior branch) and V.N. Shevkunenko (magistral, mixed, and distributed patterns) [9, 23, 24].

The length, diameter, and angle of the portal vein formation relative to the midline of the human body as well as angles of formation of the vessels forming the portal vein in the frontal plane were estimated. The measurements were performed by building a central axis of the vessel with further measuring of its linear parameters [25].

Statistical processing was carried out using the SPSS Statistics 17.0 software package. The normality distribution was assessed using the Shapiro – Wilk test. Characteristics of variational series for quantitative features with nonparametric distribution and data with parametric distribution due to their small number were presented using measures of the central tendency (mean (*M*), median (*Me*), mode (*Mo*)) and measures of variance (standard deviation, range, interquartile range [Q_{25}; Q_{75}]). When comparing two independent samples of nonparametric data, the nonparametric Mann – Whitney U-test was used.

RESULTS AND DISCUSSION

3D models of CT scans of the portal venous system among all the examined men were characterized by constant presence of the portal vein, its right branch (with the anterior and posterior branches) and left branch (with the transverse and umbilical portion), as well as splenic, superior and inferior mesenteric veins, and more superior veins, forming the main tributaries. According to X-ray, the portal vein was a cylinder with the diameter of 14.5 [13.0; 14.5] mm, and the diameter at the place of its formation was similar to the diameter of its origin. The length ranged from 58 to 71 mm and the average length was about 63 mm. The portal vein was formed at the angle of 68 [46; 72]º relative to the midline of the human body, which proves the previously published data on the frequency of the angle (Fig. 1) [6].

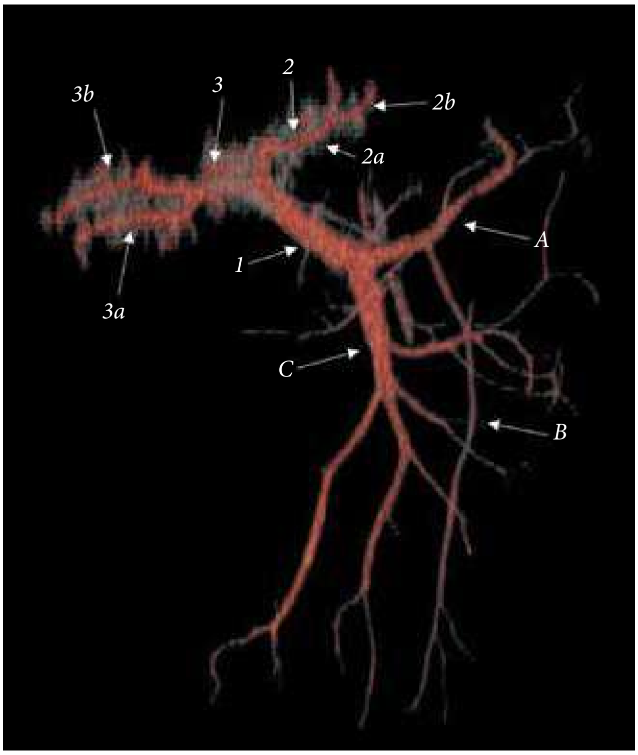

Fig. 1. 3D model of the human portal venous system. 2 – Left branch of the portal vein; 2*a* – Transverse portion; 2*b* – Umbilical portion; 3 – Right branch of the portal vein; 3*a* – Anterior branch; 3*b* – Posterior branch

Morphometric parameters of portal vein branches are shown in Table 1. Formation angles of the main branches of the portal vein were statistically different ($p < 0.05$). If the formation angle of the right main branch made 135.0 [130.0; 141.0]º, the left branch was located at an angle of 53.0 [49.5; 60.0]º relative to the portal vein. In 96% of cases, both branches were formed according to the classical branching pattern (according to the classification by T. Nakamura), and in individual cases, trifurcation and intrahepatic branching of the anterior portion occurred.

The left branch of the portal vein was longer than the right one (82.0 [79.5; 89.0] mm and 46.0 [39.5; 47.5] mm, respectively); the left and right branches had identical diameters (13.0 [10.5; 14.5] mm and 11.0 [10.5; 12.0] mm, respectively). The right branch of the portal vein was dichotomously divided into anterior and posterior branches; the length of the anterior (75.5 [73.0; 77.5] mm) and posterior (80.5 [75.5; 81.0] mm) branches and their diameters (8.0 [7.0; 8.5] mm and 7.0 [6.5; 8.5] mm) did not differ significantly, unlike the angles of their formation. The anterior branch was a kind of continuation of the right branch and departed from it at the angle of 160.0 [145.0; 170.0]º. The posterior branch formed an almost right angle with the right branch (115.0 [100.0; 125.0]º). Portions of the left branch of the portal vein had peculiarities in terms of length. The transverse portion (53.0 [48.0; 61.0] mm) was always longer than the umbilical one (31.0 [28.0; 39.0] mm), while their diameters did not differ significantly.

Table 1

Morphometric parameters of the portal vein branches found by X-ray, *Me* [P_{25}; P_{75}]

Parameter	Length, mm	Diameter, mm	Formation angle, degree*
Portal vein	63.0 [58.0; 71.0]	14.5 [13.0; 14.5]	68.0 [46.0; 72.0]
Right branch of the portal vein:	46.0 [39.5; 47.5]	11.0 [10.5; 12.0]	135.0 [130.0; 141.0]
– anterior branch	75.5 [73.0; 77.5]	8.0 [7.0; 8.5]	160.0 [145.0; 170.0]
– posterior branch	80.5 [75.5; 81.0]	7.0 [6.5; 8.5]	115.0 [100.0; 125.0]
Left branch of the portal vein:	82.0 [79.5; 89.0]	13.0 [10.5; 14.5]	53.0 [49.5; 60.0]
– transverse portion	53.0 [48.0; 61.0]		
– umbilical portion	31.0 [28.0; 39.0]		

*Formation angle of the portal vein relative to the midline of the human body

As a result, variations in the morphometric parameters of intrahepatic vessels of the portal vein are obvious. The vessels that form the portal vein are presented by three systems, each of which has a trunk and tributaries differing in the branching pattern and other morphological characteristics.

The superior mesenteric vein is characterized by the mixed branching pattern [23]. It has one trunk of 93.5 [78.5; 119.5] mm in length with the diameter of 9.5 [6.5; 12.0] mm entering the portal vein at the angle of 170.0 [160.0; 175.0]º and formed by tributary veins of most of the unpaired organs in the upper and lower abdominal cavity (Fig. 2). The tributaries of the superior mesenteric vein have almost the same diameter of 3.5–12 mm, but different length. The shortest tributaries are the jejunal vein (40.0 [38.5; 46.5] mm), the right gastroepiploic vein (45.0 [38.5; 53.5] mm), the iliac vein (50.0 [48.5; 53.5] mm), the middle colic vein (60.0 [58.5; 63.5] mm), and the ileocolic vein (70.0 [68.5; 78.5] mm). The maximum length is determined in the right colic vein (115.0 [108.5; 120.5] mm), draining the ascending and transverse parts of the colon. The convergence angles of each tributary of the superior mesenteric vein are defined by locations of the internal organs from which the venous drainage is carried out. Since iliac and ileocolic veins are caudal branches, the value of their angles approaches the flat angle and averages 160 (160.0 [155.0; 171.0]º and 160.0 [150.0; 171.0]º, respectively). The given value is the statistical maximum relative to the convergence angles of other veins in this system. The middle (120.0 [110.0; 131.0]º) and right (140.0 [130.0; 145.0]º) colic veins have the average value. The minimal values are typical of the jejunal and right gastroepiploic veins (70.0 [60.0; 81.0]º and 85.0 [80.0; 91.0]º, respectively).

The inferior mesenteric vein system contains fewer veins entering its bed compared with the superior mesenteric vein vasculature. The magistral branching pattern of the inferior mesenteric vein is found in 23% of cases, while in 77% of cases this vein is characterized by the mixed pattern (Fig. 3) [23]. In case of the mixed branching pattern, the inferior mesenteric vein enters the superior mesenteric vein between the right colic and jejunal veins. In most cases, the inferior mesenteric vein of the magistral branching pattern enters the splenic vein (Fig. 1) or is an independent tributary of the portal vein. Its diameter is significantly smaller than that of the superior mesenteric vein and reaches 4.5 [2.0; 6.5] mm. Although length values vary depending on the branching characteristics, they do not significantly differ from the values of this parameter for the superior mesenteric vein. The angle of formation, as in the case of inflow into the superior or splenic vein, ranges from 135 to 151º. Linear parameters and formation angles of the inferior mesenteric vein tributaries do not have statistically significant differences (Table 2).

Table 2

Morphometric parameters of the portal vein roots found by X-ray, *Me* [P_{25}; P_{75}]

Parameter	Length, mm	Diameter, mm	Formation angle, degree
Superior mesenteric vein:	93.5 [78.5; 119.5]	9.5 [6.5; 12.0]	170.0 [160.0; 175.0]
– middle colic vein	60.0 [58.5; 63.5]	9.0 [6.0; 11.0]	120.0 [110.0; 131.0]
– jejunal vein	40.0 [38.5; 46.5]	4.0 [3.5; 6.0]	70.0 [60.0; 81.0]
– iliac vein	50.0 [48.5; 53.5]	5.5 [5.0; 7.0]	160.0 [155.0; 171.0]
– ileocolic vein	70.0 [68.5; 78.5]	5.0 [3.5; 6.5]	160.0 [150.0; 171.0]
– right colic vein	115.0 [108.5; 120.5]	6.0 [6.5; 9.0]	140.0 [130.0; 145.0]
– right gastroepiploic vein	45.0 [38.5; 53.5]	4.0 [3.5; 6.0]	85.0 [80.0; 91.0]
Inferior mesenteric vein:	108.5 [104.0; 111.5]	4.5 [2.0; 6.5]	140.0 [135.0; 151.0]
– left colic vein	40.0 [33.5; 49.5]	3.5 [2.0; 4.5]	175.0 [170.0; 179.0]
– sigmoid vein	50.0 [27.0; 53.5]	3.0 [2.0; 3.5]	165.0 [160.0; 170.0]
– superior rectal vein	30.0 [20.0; 50.0]	3.0 [2.0; 4.0]	160.0 [155.0; 165.0]
Splenic vein:	125.0 [97.5; 129.5]	7.5 [5.5; 8.5]	100.0 [95.0; 111.0]
– left gastroepiploic vein	20.0 [13.5; 29.5]	5.0 [4.0; 6.0]	130.0 [120.0; 135.0]
– short gastric veins (*n* = 6–12)	12.0 [7.0; 18.5]	4.0 [3.0; 4.5]	90.0 [90.0; 95.0]

Unlike the superior and inferior mesenteric vein systems, the splenic vein always has the magistral branching pattern (Fig. 4). The splenic vein has medium diameter (7.5 [5.5; 8.5] mm) and maximum length (125.0 [97.5; 129.5] mm) values and enters the portal vein at a smaller angle (100.0 [95.0; 111.0]º) than in case of the superior and inferior mesenteric veins. Tributaries of the splenic vein are numerous, values of the linear parameters do not differ significantly. The average values for the length, diameter, and convergence angle of the left gastroepiploic vein are 20.0 [13.5; 29.5] mm, 5.0 [4.0; 6.0] mm, and 130.0 [120.0; 135.0]º, respectively. The short gastric veins enter the splenic vein at a right angle (90.0 [90.0; 95.0]º), and the average values for their length and diameter reach 12.0 [7.0; 18.5] mm and 4.0 [3.0; 4.5] mm, respectively.

Radiographic testing of the portal venous system using MSCT with bolus tracking has shown high information capacity, which had been previously demonstrated by A.V. Kolsanov et al. [9].

Estimating the length, diameter, and formation angles of the portal vein and its tributaries, we came to the conclusion that modern diagnostic imaging techniques with the use of contrast agents should be used to study the portal venous system at various levels of its structural organization.

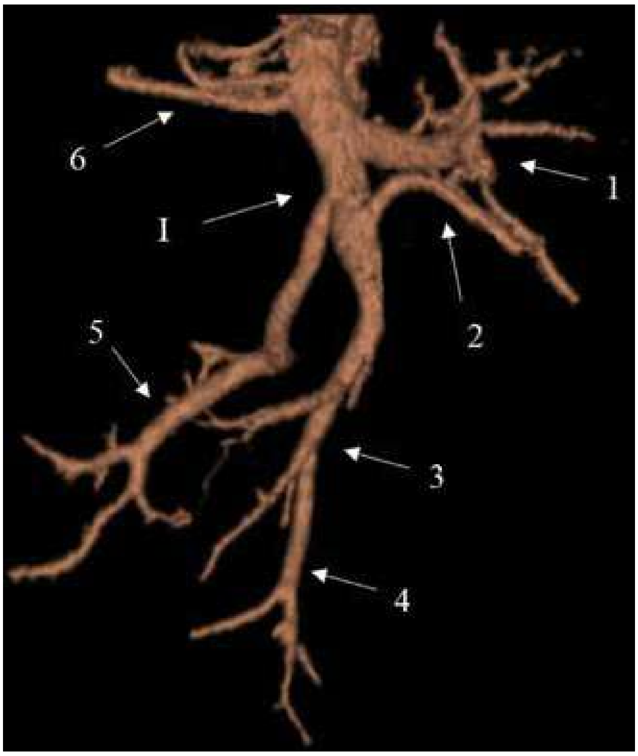

Fig. 2. 3D model of the human superior mesenteric vein: I – superior mesenteric; 1 – middle colic vein; 2 – jejunal vein; 3 – Iliac vein; 4 – Ileocolic vein; 5 – Right colic vein; 6 – Right gastroepiploic vein

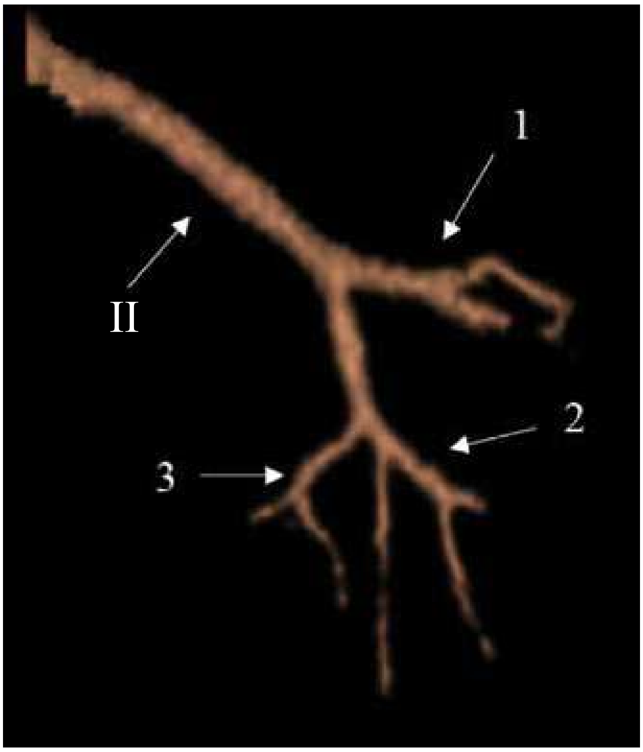

Fig. 3. 3D model of the human inferior mesenteric vein: II – Inferior mesenteric vein; 1 – Left colic vein; 2 – Sigmoid vein; 3 – Superior rectal vein

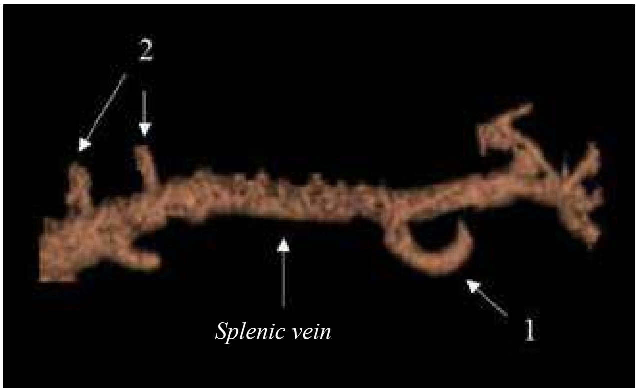

Fig. 4. 3D model of the human splenic vein: 1 – Left gastroepiploic vein; 2 – Short gastric veins

CONCLUSION

The current study provides quantitative landmarks for the major venous structures in the portal venous system. The research results made it possible to supplement scientific materials regarding the branching patterns and morphological parameters of the portal vein and its branches. The obtained data reflecting morphometric characteristics of the superior and inferior mesenteric veins as well as splenic vein prove variability of veins included in the *v. portae* system and a wide range of its structural anatomy and can be used to resolve the issues of surgical intervention on the abdominal organs. Variations typical of each venous system should be taken into account when choosing the strategy of managing patients with portal hypertension or at the preoperative stage.

REFERENCES

1. Khamanarong K., Woraputtaporn W., Amarttayakong P., Ahooja A., Khuntikeo N. Classification of portal vein tributaries in Thai cadavers including a new type V. *Surgical and Radiologic Anatomy.* 2016; 38 (6): 735–739. DOI: 10.1007/S00276-015-1592-7.
2. Sharma V., Chauhan R.S., Sood R.G., Makhaik S., Negi K., Chawla K., Diwan Y., Partap A., Rana S., Gupta A. Study of the normal anatomy and variations of portal vein in North Indian population: a MDCT study. *European Journal of Anatomy.* 2017; 21 (1): 13–18.
3. Cheluvashetty S.B., Rachapalli V. Unusual branching pattern of the portal vein: its importance. *Journal of Clinical and Diagno*stic Research. 2017; 11 (8): TD01–TD02. DOI: 10.7860/JCDR/2017/29011.10390.
4. Guerra A., De Gaetano A.M., Infante A., Mele C., Marini M.G., Rinninella E., Inchingolo R., Bonomo L. Imaging assessment of portal venous system: pictorial essay of normal anatomy, anatomic variants and congenital anomalies. *European Review for Medical and Pharmacological Sciences.* 2017; 21 (20): 4477–4486.
5. Kovalenko N.A., Gaivoronsky I.V., Kotiv B.N., Tyagun V.S., Novitskaya N.Yu. Variant anatomy of the portal vein and its

application in surgery. *Medline.ru. Russian Biomedical Journal.* 2018; 19 (1): 182–208 (in Russ.).
6. Gaivoronskiy I.V., Kotiv B.N., Kovalenko N.A., Lazarenko V.A. Variant anatomy of the great vessels of the portal vein system and its applied significance. *Kursk Scientific and Practical Bulletin "Humans and Their Health".* 2018; 2: 70–75 (in Russ.). DOI: 10.21626/vestnik/2018-2/11.
7. Russkikh A.N., Shabokha A.D., Gorbunov N.S., Derevtsova S.N. Features of the local constitution in the structure of the veins of the human rectum. *Bulletin of New Medical Technologies.* 2013; 20 (2): 53–57 (in Russ.).
8. Iqbal S., Iqbal R., Iqbal F. Surgical implications of portal vein variations and liver segmentations: a recent update. *Journal of Clinical and Diagnostic Research*. 2017; 11 (2): AE1–AE5. DOI: 10.7860/JCDR/2017/25028.9453.
9. Kolsanov A.V., Zelter P.M., Manukyan A.A., Chaplygin S.S., Ivanova V.D. Studying the anatomy of the portal vein using the preoperative planning system. *Operative Surgery and Clinical Anatomy.* 2017; 1 (2): 3–6 (in Russ.). DOI: 10.17116/operhirurg2017123-6
10. Nakamura T., Tanaka K., Kiuchi T., Kasahara M., Oike F., Ueda M., Kaihara S., Egawa H., Ozden I., Kobayashi N., Uemoto S. Anatomical variations and surgical strategies in right lobe living donor liver transplantation: lessons from 120 cases. *Transplantation.* 2002; 73 (12): 1896–1903. DOI: 10.1097/00007890-200206270-00008.
11. Schmidt S., Demartines N., Soler L., Schnyder P., Denys A. Portal vein normal anatomy and variants: Implication for liver surgery and portal vein embolization. *Semin Intervent. Radiol.* 2008; 25 (2): 86–91. DOI: 10.1055/S-2008-1076688.
12. Sakamoto Yo., Kokudo N., Kawaguchi Yo., Akita K. Clinical Anatomy of the Liver: Review of the 19th Meeting of the Japanese Research Society of Clinical Anatomy. *Liver Cancer.* 2017; 6 (2): 146–160. DOI: 10.1159/000449490.
13. Akagi M., Nakamura Yu., Higaki T., Narita K., Honda Yu., Zhou J., Yu Z., Akino N., Awai K. Deep learning reconstruction improves image quality of abdominal ultra-high-resolution CT. *European Radiology*. 2019; 29 (11): 6163–6171. DOI: 10.1007/S00330-019-06170-3.
14. Karunakaravel K. Utility of cone-beam computed tomography in the assessment of the porto-spleno-mesenteric venous system. *Cardiovascular Diagnosis and Therapy.* 2016; 6 (6): 544–556. DOI: 10.21037/CDT.2016.11.16.
15. Russkikh A.N., Shabokha A.D. X-ray examination methods of veins of the human rectum. *Bulletin of Siberian Medicine*. 2019; 18 (2): 146–156 (in Russ.). DOI: 10.20538/1682-0363-2019-2-146-156
16. Volkova S.N., Stashuk G.A., Chermensky G.V., Naumov E.K. The role of MRI in identifying extramural vascular invasion as an indicator of the presence of regional and distant metastases of the lower ampullary rectum cancer. *Experimental and Clinical Gastroenterology.* 2019; 4 (164): 66–71 (in Russ.). DOI: 10.31146/1682-8658-ECG-164-4-66-71.
17. Takahiro S., Katsu Ya., Jouji T., Yoshiyasu K., Takumi O., Jun A. Diagnosis of rectal varices via color Doppler ultrasonography. *The American Journal of Gastroenterology.* 2007; 102 (10): 2253–2258. DOI: 10.1111/J.1572-0241.2007.01340.X.
18. Cyriac A.Ph., Philip A. Endoscopic ultrasound-guided management of bleeding rectal varices. *ACG Case Reports Journal.* 2017; 4: e101. DOI: 10.14309/CRJ.2017.101.
19. Lang H., de Santibañes E., Schlitt H.J., Malagó M., van Gulik T., Machado M.A., Jovine E., Heinrich S., Ettorre G.M., Chan A., Hernandez-Alejandro R., Campos R.R., Sandström P., Linecker M., Clavien P.-A. 10th Anniversary of ALPPS-lessons learned and quo vadis. *Annals of Surgery*. 2019; 269 (1): 114–119. DOI: 10.1097/SLA.0000000000002797.
20. Durand C.A.L., Rázuri C.B., Valderrama M.W., Arredondo G.M., Ramos D.S. The human liver: vascular anatomy to determine its segments and divisions. *International Journal of Morphology.* 2020; 38 (1): 226–229. DOI: 10.4067/S0717-95022020000100226.
21. Singh H.R., Rymbai M.L., John R., Eapen A., Rabi S. Branching pattern of the portal vein in Indian population. *European Journal of Anatomy.* 2019; 23 (6): 425–433.
22. Carneiro C., Brito Jo., Bilreiro C., Barros M., Bahia C., Santiago I., Caseiro-Alves F. All about portal vein: a pictorial display to anatomy, variants and physiopathology. *Insights into Imaging.* 2019; 10 (1): 38. DOI: 10.1186/S13244-019-0716-8.
23. Shevkunenko V.N. Atlas of peripheral nervous and venous systems. *Moscow: MEDGIZ,* 1949: 345 (in Russ.).
24. Gadzijev E.M. Atlas of applied internal liver anatomy. Foreword by Stig Bengmark. Wien. New York: Springer, 1996; 204.
25. Covey A.M., Brody L.A., Getrajdman G.I., Sofocleous C.T., Brown K.T. Incidence, patterns, and clinical relevance of variant portal vein anatomy. *Am. J. Roentgenol*. 2004; 183 (4): 1055–1064. DOI: 10.2214/AJR.183.4.1831055.

Authors information

Russkikh Andrey N., Cand. Sci. (Med.), Associate Professor, Head of the Department of Operative Surgery and Topographic Anatomy, V.F. Voino-Yasenetsky Krasnoyarsk State Medical University, Krasnoyarsk, Russian Federation.

Shabokha Anna D., Cand. Sci. (Med.), Assistant, Department of Outpatient Pediatrics and Propaedeutics of Childhood Diseases with a Course of Graduate Training, V.F. Voino-Yasenetsky Krasnoyarsk State Medical University, Krasnoyarsk, Russian Federation.

Tyumentsev Nikolay V., Assistant, Department of Radiodiagnostics of the Postgraduate Education Institute, V.F. Voino-Yasenetsky Krasnoyarsk State Medical University, Krasnoyarsk, Russian Federation.

Derevtsova Svetlana N., Dr. Sci. (Med.), Professor, Department of Human Anatomy and Histology, V.F. Voino-Yasenetsky Krasnoyarsk State Medical University, Krasnoyarsk, Russian Federation.

(✉) **Shabokha Anna D.,** e-mail: tat_yak@mail.ru.

Received 02.06.2020
Accepted 28.12.2020