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Research Article

Morphological investigation of the veins and bile vessels of rabbit liver

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ABSTRACT

The focus was to investigate the anatomical specifics of v. portae, vv. hepaticae and ductus choledochus by corrosion. We investigated 10 sexually mature, clinically healthy New Zealand White rabbits, 8 months old, weighing 2.8 kg to 3.2 kg. To determine the veins and bile vessels, a cold-curing acrylic-based plastic (Duracryl +) was used. The main portal vessel was an intra-organic continuation of v. portae, after its branching into caudate lobe. The main portal vein was divided into v. portae dextra and v. portae sinistra, when entering lobus hepatis dexter and lobus hepatis sinister. V. portae sinistra caudalis was a branch of v. portae sinistra. The venous drainage of the rabbit liver in was carried out by v. hepatica sinistra caudalis, v. hepatica sinistra, v. hepatica dextra, v. hepatica media and venous vessel in lobus caudatus. V. hepatica sinistra and v. hepatica media had a common origin and took blood from lobus hepatis sinister medialis. V. hepatica dextra drained lobus hepatis dexter. V. hepatica sinistra caudalis was a direct tributary of the caudal vena cava. Ductus hepaticus communis was well developed and collected the bile from the main bile duct. Ductus hepaticus dexter drained lobus hepatis dexter and evacuated the bile into the main bile duct. Ductus hepaticus sinister caudalis flowed directly into ductus hepaticus communis. Ductus hepaticus sinister passed into the main bile duct.

INTRODUCTION

The anatomical features of the liver vessels in New Zealand white rabbits are similar to those in humans. Therefore, this species has been used as an anatomical model to study portal and hepatic veins in humans (Mapara et al., 2012).

Corrosion anatomical study of the liver in carnivores and humans is an appropriate method for studying variations in the morphological features of the liver vessels (Matusz, et al., 2007; Uršič et al., 2007).

According to De Graaf et al. (2011) the rabbit liver consists of four parts. The three cranial lobes are lobus hepatis dexter, lobus hepatis sinister medialis and lobus hepatis sinister lateralis, and the caudal lobe is lobus caudatus. In each lobe the portal vein sends branches.

Specific to the rabbit□s liver is that the cranial lobes are separated from the caudate lobe. The portal vein in the rabbit at the entrance to the liver is divided into a branch for the lobus caudatus and a main porta vessel. The main portal vein is subdivided into v. portae sinistra and v. portae dextra. V. portae sinistra sends a medial and lateral branch to lobus hepatis sinister medialis and lobus hepatis sinister lateralis. V. portae sinistra inferior is defined as an additional branch starting from the left portal or from the main portal vein (Seo et al. 2001; Páramo et al., 2017).

According to Barone (1997) and Barone (2011), the portal vein in the rabbit has two branches - left and right. The left branch supplies blood to lobus hepatis sinister medialis, lobus hepatis sinister lateralis and lobus quadratus, and the right branch – to lobus hepatis dexter.

The data from the corrosion method of the study of portal vessels in humans are used as a morphological basis for the interpretation of anatomical findings obtained in selective portography (Sinelnikov, 1973).

In the mole, eight hepatic veins have been described, which drain blood from the liver in v. cava caudalis. Proc. caudatus and lobus hepatis dexter lateralis have separate venous drainage from two separate hepatic veins. They unite in a common vein, which is an inflow of the caudal vena cava. Lobus hepatis dexter medialis, proc. papillaris and lobus quadratus are drained by three hepatic veins, which are also tributaries of the caudal vena cava. In the left hepatic lobe are found four vv. hepaticae (Nešić1 et al., 2020).

According to Carlisle et al. (1995) each hepatic lobe in the dog has a separate hepatic vein. The following hepatic veins are distinguished: left lateral and left medial vein, hepatic vein in lobus quadratus, right lateral and right medial vein, hepatic vein in proc. papillaris and hepatic vein in proc. caudatus.

According to Mari and Acocella (2015) ,the dog□s liver is divided into two sections, three subsections, seven sections and two to four subsections. The right section is drained by separate hepatic veins, while most of the left section is drained

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by the main hepatic vein formed by the fusion between the middle and left hepatic veins. Part of lobus hepatis dexter and proc. papillaris is drained directly by v. cava caudalis. The right hepatic vein drains only lobus hepatis dexter.

The venographic presentation of vv. hepaticae in the rabbit visualizes five separate vessels. Lobus caudatus has a separate venous drainage. V. hepatica sisnistra caudalis is a direct branch of caudal vena cava and determines the independent venous drainage of the left lateral hepatic lobe (Seo et al., 2001; Stamatova-Yovcheva, 2016; Stamatova-Yovcheva et al., 2018).

According to Barone (2011), ductus hepaticus communis is absent in the rabbit. The left bile duct drains lobus hepatis sinister medaialis, lobus hepatis sinister lateralis and lobus quadratus. The right bile duct drains lobus hepatis dexter and lobus caudatus. Ductus cysticus and ductus hepaticus sinister form ductus choledochus, and ductus hepaticus dexter joins ductus choledochus.

Alloush (1997) presented data on the presence of a separate ductus hepaticus communis in the rabbit, formed by the fusion of the left and right bile ducts, ventrally from porta hepatis. Ductus hepaticus communis joins the bile duct in proc. caudatus, at its transition into lig. hepatoduodenale.

According to other authors (Stamatova-Yovcheva, 2016; Stamatova-Yovcheva et al., 2018), the liver of the rabbit has a well-defined ductus hepaticus communis. The main biliary duct is a continuation of ductus hepaticus communis. Ductus hepaticus sinister caudalis is an independent direct branch of the common biliary duct and is located in lobus hepatis sinister lateralis. Ductus hepaticus sinister and ductus hepaticus dexter form the main biliary duct.

Sinelnikov (1973) describes the biliary tree in humans through comparative corrosion and contrast anatomical analysis, establishing compliance.

From the presented data it is evident that the anatomical results for the liver of the rabbit are contradictory and insufficient. Corrosion anatomical studies of this organ complement the findings of previous studies. Therefore, the reason for the present study is the expected results for the interpretation of the morphological features of the venous and bile vessels in the rabbit.

MATERIAL and METHODS

The study included 10 sexually mature, clinically healthy rabbits, 8 months old, of the New Zealand White breed, weighing 2.8 kg to 3.2 kg. In the studied animals, dissection was performed according to the algorithm described by Bensley (1948), Wingerd (1985), Yonkova, (2014) and Stamatova-Yovcheva (2016) for the rabbit.

Preparation of corrosion macroscopic preparations of v. portae and its branches we cannulated the portal vein, caudally from the pancreas. V. portae was ligated into the Th13-L1 segment. The carcasses were dissected in the segment from Th13 to L4. We applied an injection in v. portae of cold-curing acrylic-based plastic (Duracryl +, two-component SpofaDental, Chech Republic), according to the following prescription: -10 g purple colorant (TS, DEUTEK S.A.) was added to 30 g of the powdered component Duracryl +, two component, 30 g of hardener Duracryl + was added to the mixture. We injected 10 mL of the resulting homogenized solution into the cannula using a syringe. We placed the carcass segments at a refrigeration temperature (+ 4C °) for 24 hours, then moved them to a polyvinyl container with a lattice bottom. In a PVC vessel with a capacity of 7 L to 1.5 L of water we added 3 L of hydrochloric acid (38% h. HCL, MARVIN Ltd., Dimitrovgrad) (ratio 1: 2). We placed the lattice vessel in the vessel containing hydrochloric acid and water for a period of 48 hours. The corrosion preparations were washed in a weak water stream. The obtained results were photo-documented.

Preparation of corrosion macroscopic preparations from vv. hepaticae we investigated the localization of v. cava caudalis in the segment from Th10 to L3 in three rabbits. We cannulated the caudal vena cava at the L2 level. For greater clarity, we simultaneously filled with the cold polymer paste v. cava caudalis and ductus choledochus. For the injection of v. cava caudalis blue dye was used and for ductus choledochus – yellow dye.

Preparation of corrosion preparations from the gallbladder and bile vessels. We studied the topography of the liver, gallbladder, ductus choledochus, stomach and pars cranialis duodeni in four rabbits. A curved intestinal clamp was placed on pars cranialis duodeni, 20 mm caudally from the pylorus. The liver, stomach and pars cranialis duodeni were extirpated and placed in a 0.6 / 1.0 L Simax beaker (Czech Republic). The organs were washed under running water for 30 minutes. We applied a longitudinal incision on the antimesenteric wall of pars cranialis duodeni. Papilla duodeni major was cannulated by pyrogen-free cannula (PROBIO-silicone carbide, G18) with sequence number 18 in ductus choledochus. We used yellow colorant. We introduced 5 mL of the resulting homogenized solution into papilla duodeni major. The studied group of organs (liver, stomach and pars cranialis duodeni) were stored at refrigeration temperatures (+ 4C °) overnight. The rest of the research methodology coincides with the steps described for v. portae.

RESULTS

Corrosion anatomical study revealed that the main portal vessel was an intraorganic continuation of v. portae. It was divided into v. portae dextra and v. portae sinistra, when entering lobus hepatis dexter and lobus hepatis sinister. V. portae sinistra caudalis was a branch of v. portae sinistra in lobus hepatis sinister lateralis. The left portal vein was further divided into a lateral branch in lobus hepatis sinister lateralis and a medial branch in lobus hepatis sinister medialis. V. portae dextra was a single vessel in lobus hepatis dexter. The venous vessel, which was located dorsally from the portal vein, was a direct branch of v. portae and entered lobus caudatus (Figure 1 and Figure 2)

The venous drainage of the rabbit liver in was carried out by five hepatic veins: v. hepatica sinistra caudalis, v. hepatica sinistra, v. hepatica dextra, v. hepatica media and venous

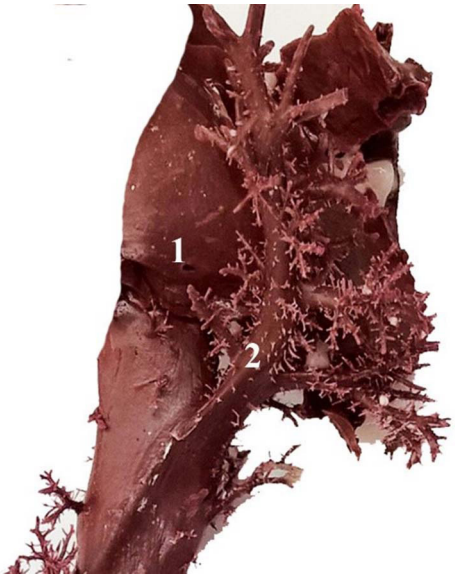

Figure 1. Corrosion anatomical image of a fragment of v. portae. (1) v. portae; (2) a branch of v. portae in lobus caudatus.

Figure 2. Corrosion anatomical image of a fragment of the main portal vessel and its branches in the rabbit liver. (1) main portal vessel; (2) v. portae dextra; (3) v. portae sinistra; (4) lateral branch of v. portae sinistra; (5) medial branch of v. portae sinistra (6) v. portae sinistra caudalis.

vessel in lobus caudatus. Vv. hepaticae in the rabbit did not have extraorganic areas and were visceral tributaries of v. cava caudalis. Lobus caudatus had a separate venous vessel that was a direct inflow of caudal vena cava (Figure 3).

Lobus hepatis sinister lateralis had a separate venous drainage, which was carried out by v. hepatica sinistra caudalis, a direct inflow of v. cava caudalis. The latter sent smaller branches in the dorsal, middle and ventral areas of the lateral left lobe. V. hepatica sinistra and v. hepatica media had a common origin and took blood from lobus hepatis sinister medialis. In lobus hepatis dexter was found v. hepatica dextra. V. hepatica media drained blood from lobus hepatis dexter and gallbladder (Figure 4).

Ductus hepaticus communis collected bile from the main bile duct. Ductus hepaticus dexter drained lobus hepatis dexter and evacuated the bile into the main bile duct. Ductus hepaticus sinister caudalis flowed directly into ductus hepaticus communis. Ductus hepaticus sinister passed into the main bile duct between lobus hepatis sinister medialis and lobus hepatis dexter. In lobus hepatis sinister medialis, ductus hepaticus sinister received bile from medial and lateral branches. The medial branch drained lobus hepatis sinister medialis, and the lateral one drained lobus hepatis sinister medialis and lobus quadratus. Ductus cysticus originated from the gallbladder and

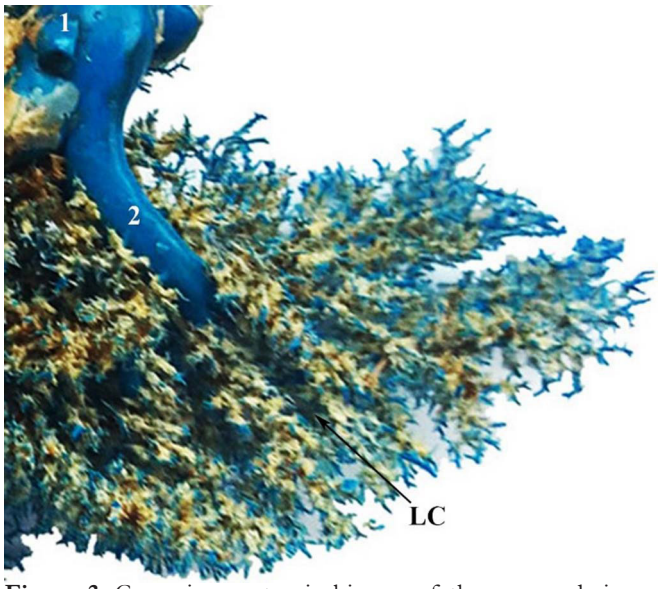

Figure 3. Corrosion anatomical image of the venous drainage in lobus caudatus in rabbit. (1) v. cava caudalis; (2) a venous vessel in lobus caudatus.

Figure 4. Corrosion anatomical image of fragment from rabbit liver. (1) v. cava caudalis; (2) v. hepatica sinistra caudalis; (3) v. hepatica sinistra; (4) v. hepatica media; (5) v. hepatica dextra; (6) vesica fellea; (7) v. cystica; LHSL – lobus hepatis sinister lateralis; LHSM-lobus hepatis sinister medialis; LHD – lobus hepatis dexter.

joined the main bile duct. Lobus caudatus had a separate bile drainage from a direct branch of ductus hepaticus communis (Figure 5).

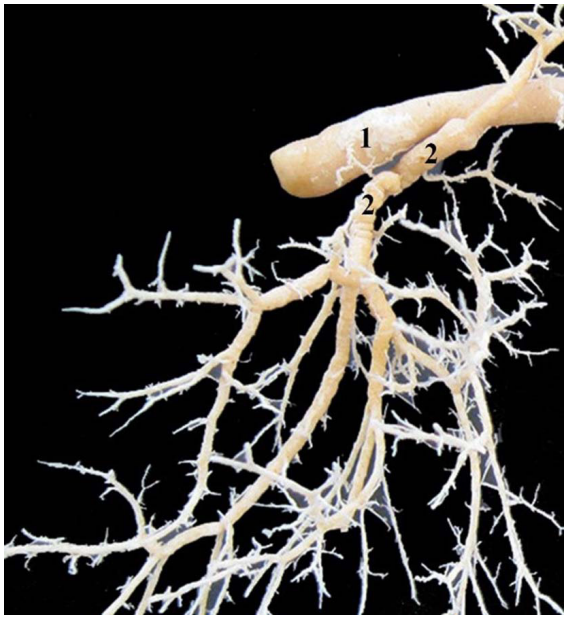

Figure 5. Corrosion anatomical image of fragment from ductus hepaticus communis in the rabbit. (1) ductus hepaticus communis; (2) ductus hepaticus sinister caudalis.

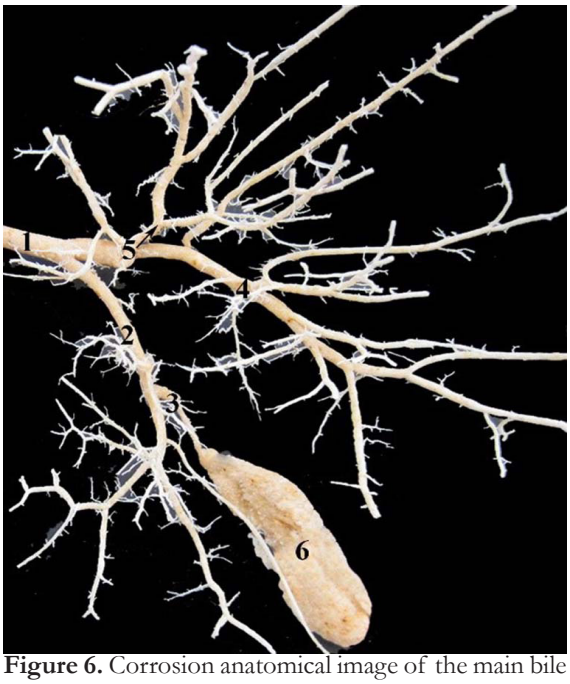

Figure 6. Corrosion anatomical image of the main bile duct in the rabbit (1) main bile duct; (2) ductus hepaticus sinister (3) ductus cysticus; (4) ductus hepaticus dexter; (5); bile duct in lobus caudatus (6) vesica fellea.

DISCUSSION

We present a modern view of the terminological justification of portal vessels in the rabbit. In our opinion, each unit has its own portal blood supply. Our hypothesis corresponds to the opinion of De Graaf et al. (2011) for the portal vascularization of the liver in the rabbit.

We consider that v. portae sinistra caudalis is a specific vessel for lobus hepatis sinister lateralis in the rabbit. In our opinion, the venous supply of lobus hepatis sinister medialis is carried out by v. portae sinistra medialis, the lateral branch of v. portae sinistra supplies lobus hepatis sinister lateralis, and

v. portae dextra supplies lobus hepatis dexter. Our hypothesis gives us reason to support the findings of Seo et al. (2001) and Páramo et al. (2017) on the morphology of the hepatic portal system in rabbits.

Our assertion is that the portal vessels in the rabbit are v. portae sinistra, v. portae sinistra caudalis, v. portae dextra and a portal vessel in lobus caudatus does not support the view of Barone (1997) and Barone (2011) that portal vascularization in the rabbit liver is performed only by v. portae dextra and v. portae sinistra.

We argue that the direct portal branch for lobus caudatus separates before the main portal vein and that the continuation of the portal vein after lobus caudatus is the main portal vessel that provides the branches for the remaining parts of the liver. Our thesis corresponds to previous research in this direction (Stamatova-Yovcheva, 2016; Stamatova-Yovcheva et al., 2018)., concerning the portal blood supply of the liver in the rabbit.

The found five hepatic veins the rabbit liver did not correspond to the describtion of Nešić et al. (2020) about the hepatic vascularization in the mole.

We argue that only lobus caudatus and lobus hepatis sinister lateralis have a separate venous drainage, which differs from the opinion of Carlisle et al. (1995) and Mari and Acocella (2015) for the venous drainage in the liver of the dog and complements the findings of some authors on the hepatic veins in rabbits (Seo et al., 2001; Stamatova-Yovcheva, 2016; Stamatova-Yovcheva et al., 2018).

The anatomical data obtained by us from the corrosion anatomical examination of the bile ducts are convincing enough and present information about the presence of ductus hepaticus communis in the rabbit. Our data differ from the thesis of Barone (2011), according to which ductus hepaticus communis in rabbits is missing and complements the published data on the morphological features of the bile ducts in rabbits (Alloush, 1997; Stamatova-Yovcheva, 2016; Stamatova-Yovcheva et al., 2018).

The results presented by us from the corrosion of the organ, which concern the course of the venous and bile vessels in the liver of the rabbit is a valid criterion for accepting the reliability of the method. Therefore, we can support the opinion of some authors (Matusz, et al., 2007; Uršič et al., 2007, Sinelnikov, 1973) about humans and carnivores, for the application of the corrosion method in the study of the liver in rabbits.

CONCLUSION

The corrosion anatomical study of the blood and bile vessels in the rabbit gives a detailed picture of the macroarchitectonics of these vessels. We propose that our results can be used as a morphological basis in the corrosion study of the hepatic blood and bile vessels in other mammals and humans.

DECLARATIONS

Ethics Approval

The experiments were conducted in strict compliance with the ethical guidelines of Trakia University (protocol 209/24.10.20 12;213/14.11.2012;220/12.12.2012; 231/04.02.2013).

Conflict of Interest

The authors declare that there have no conflict of interests.

Author Contributions

Idea, concept and design: KSY, RD, ÖG.

Data Collection and analysis: KSY, RD, DY.

Drafting of the manuscript: KSY, ÖGD.

Critical review: KSY, RD, ÖGD, DY.

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