Case Report

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Rare variation of the branches of the coeliac trunk and the common hepatic artery in human cadaver: a case report

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Background: The liver with its dual blood supply from the portal vein and the common hepatic artery (CHA) is unique among parenchymal organs. CHA accounts for around 30% of blood flow to the liver but has a central role in hepatobiliary perfusion.
Case presentation: We demonstrated a rare case of unusual branching of the CHA during routine dissection of an embalmed female cadaver. Measurements of the diameter and distance of origin of the branches were performed. The coeliac trunk presented with five branches – left gastric, splenic, CHA, right inferior phrenic, and accessory left hepatic arteries. The CHA pentafurcated into the left hepatic (LHA), middle hepatic (MHA), right hepatic (RHA), cystic (CA), right gastric (RGA), and gastroduodenal arteries (GDA). The first branch presented was RGA to the lesser curvature of the stomach. Instead of proper hepatic artery, three branches were observed – LHA, MHA, and posteriorly and between them, RHA. Inferiorly the GDA, with its diameter of 4 mm, represented a direct continuation of CHA. Accessory RHA artery was also identified branching from superior mesenteric artery.
Discussion: Variations of the hepatic arterial blood supply are seen in more than half of the population. The described variations were not previously identified according to the available literature.
Conclusion: Such complex variation, as the one presented in the current case, represents significant deviation from the norm. In the past, they were considered anatomical curiosities but now, in the era of complex liver surgeries and arterial-directed therapies, their relevance is being highly recognized.

Keywords: accessory right hepatic artery, case report, coeliac trunk, common hepatic artery, middle hepatic artery

Introduction

The liver is unique among parenchymal organs with its dual blood supply from the portal vein (PV) and the common hepatic artery (CHA). The CHA provides only around 30% of blood flow to the liver but has a central role in hepatobiliary perfusion. Normally, the coeliac trunk (CT) originates from the aorta as an unpaired visceral branch. It then trifurcates into the left gastric artery (LGA), the splenic artery (SA), and the CHA, which shortly after divides into the gastroduodenal artery (GDA) and the proper hepatic artery (PHA). The PHA divides into two main branches: the right hepatic (RHA) and the left hepatic arteries (LHA) supplying the eight segments of the liver. The right gastric artery (RGA) also usually originates from the PHA. The classical branching pattern of CHA was found in 55%–75.7% of the cases[1–4]. Michels[1] introduced a classification system that described the main variations of the vascular anatomy of the liver. This classification system was modified by Hiatt *et al*[3] and supplemented by Koops *et al*[2]. Despite such complex classifications, there were rare variations that did not fit any of them[5–8]. Here, we present pentafurcation of the CHA which was not previously described and should be an extremely rare hepatic artery variant. Trifurcation and quadrifurcation of CHA were

HIGHLIGHTS

- We demonstrated a rare case of unusual branching of the common hepatic artery during routine dissection of an embalmed female cadaver.
- The coeliac trunk presented with five branches – left gastric, splenic, common hepatic, right inferior phrenic, and accessory left hepatic arteries.
- The common hepatic artery pentafurcated, 23.9 mm from its origin from the coeliac trunk, into the left hepatic, middle hepatic, right hepatic, cystic, right gastric, and gastroduodenal arteries.
- Accessory right hepatic artery was also identified branching from superior mesenteric artery.

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found in 7.16% and 2.16% of the cases, respectively[9]. Moreover, middle hepatic artery (MHA), which usually supplies segment IV (lobus quadratus) of the liver, was derived directly from CHA as one of the five branches.

Knowledge of the variant vascular anatomy of upper gastrointestinal region is valuable to hepatobiliary surgeons to minimize operative complications due to unexpected bleeding during liver and biliary tree intervention or pancreatoduodenectomy. In liver transplantations, for example, it is of crucial importance to observe and describe the hepatic vascular blood supply for variations. This aims to avoid severe complications such as hepatic artery stenosis and thrombosis both in the donor and the recipient[10–12]. Especially in living donor liver transplantations, injuries to MHA might have, as a consequence, a reduction of the functional volume of the left lobe and decrease in the blood supply to the bile ducts. Frequently, unplanned surgical decisions might be taken due to the presence of arterial variations and specific tumor involvement. In such cases, there are four surgical options for managing variant vessels: sacrifice, preoperative embolization, dissection and preservation, and transection and reconstruction. Identification of the hepatic artery variations prior to surgical or radiological interventions and planning of the management is the ideal approach.

Case presentation

During routine academic dissection of the abdominal region of an embalmed female cadaver, the origin and the position of the CT and its branches, the PV, the common bile duct (CBD), and the superior mesenteric artery (SMA) were determined. Special attention was paid to the dissection of omentum minus and the characteristics of the CHA and its branches. Liver resection was performed, followed by meticulous dissection of all arterial branches supplying the liver lobes. The diameter of the branches was measured using a Vernier caliper. During the procedure, the cadaver remained in the supine position on the dissecting table. The cadaver was property of the Department of Anatomy, Histology, Cytology, and Biology, Medical University – Pleven and all procedures complied with the ethical principles outlined in the Declaration of Helsinki of 1975 (revised 2013; https://www.wma.net/policies-post/wma-declaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/). Clinical history was available without any reference to vascular surgical intervention or liver disease. Written informed consent was obtained from the patient next of kin for publication and any accompanying images. The authors sincerely thank those who donated their bodies to science. The case has been reported in line with the SCARE 2023 criteria[13].

The CT was the first unpaired visceral branch of the abdominal aorta (Fig. 1a and b; Fig. 2a and b; Fig. 3). From the right side of the CT, 1.4 mm from its origin, arose the right inferior phrenic artery with a diameter of 2.3 mm and ran upwards to the diaphragm (Fig. 1b; Fig. 2a and b; Table 1). A branch, directed to the liver, originated from the anterior surface of the CT, 11 mm from its origin. This artery was identified as an accessory left hepatic artery (aLHA) with diameter of 2.1 mm (Fig. 1a and b; Fig. 2a and b; Fig. 3; Table 1). When followed, the aLHA gave two gastric branches (Fig. 1a; Fig. 2a; Fig. 3) and on reaching the visceral surface of the liver it entered deep into fissura lig. venosi to supply liver segments II and III of the left lobe (Fig. 3). The rest of the branches of the coeliac axis were the LGA arising 14.6 mm from the beginning of CT, SA, and CHA that arose together, 19.5 mm from the origin of the CT (Fig. 1a and b; Fig. 2a and b; Fig. 3; Table 1). The LGA appeared on the anterior side of the CT coursing upwards and to the left. The SA ran a tortuous course toward the spleen. The CHA had a diameter of 4.8 mm and continued through omentum minus anteriorly to the PV (Fig. 1a and b; Fig. 2a and b; Fig. 3; Table 1). The CHA pentafurcated, 23.9 mm from its origin from the CT, into the LHA, MHA, RHA, cystic artery (CA), RGA, and GDA (Fig. 1a and b; Fig. 2a and b; Fig. 3; Table 1). The diameter of the LHA, MHA, and RHA was 2.3, 1.7, and 2 mm, respectively. The RHA was located posteriorly and to the right of the LHA and MHA in lig. hepatoduodenale (Figs. 1a and 2a; Table 1). The CA with its diameter of 1.7 mm was coursing toward the gall bladder and passing anteriorly to the CBD (Fig. 1a and b; Fig. 2a; Fig. 3). The GDA appeared as a continuation of the CHA with a diameter of 4.0 mm. The RGA, with its diameter of 1.8 mm, emerged anterior to the site of the penrtfurcation and was directed to the lesser curvature of the stomach (Fig. 1a and b; Fig. 2a; Table 1). When further dissection of the liver parenchyma was conducted around porta hepatis it was identified that the LHA coursed toward fissura lig. venosi to supply segments II and III of the liver; the MHA, just before entering deep into fissura umbilicalis, split into two branches – one for lobus quadratus (segment IVb) and one for the left lobe; while the RHA passed anterior to the CBD to supply segment V of the right lobe (Fig. 3).

Continuing the dissection of the structures in omentum minus, accessory right hepatic artery (aRHA) was identified that passed behind the PV (Fig. 1a and b). When followed down to its origin it was found that this artery was a branch of the SMA. It branched 15.3 mm from the beginning of the SMA and had a diameter of 2.2 mm (Fig. 2a; Table 1). When followed distal toward the liver, the artery was identified to enter the right lobe (Fig. 3).

Variation of the position of the structures inside lig. hepatoduodenale of omentum minus also appeared. Most anteriorly the CHA with its pentafurcation was presented. Posteriorly to that, the PV was found. Laterally to these structures and posterior to the CA, the CBD was located. The aRHA was found posteriorly to the PV (Fig. 1a and b; Fig. 2a).

Discussion

Variations of the hepatic arterial blood supply are seen in more than half of the population[1–4]. Classifications describing the principal variations in the vascular anatomy of the liver were proposed by several authors[1–3]. Despite the comprehensiveness of these classifications, there were still some rare variations that fall outside their scope[5–8]. Here, we described pentafurcation of the CHA into LHA, MHA, RHA, CA, GDA, and RGA together with the persistence of accessory branches in the form of aLHA and aRHA coming from the CT and SMA, respectively. PHA was not present. The presence of such anatomic variation was not previously identified according to the available literature, so it might be a very rare variation. Recent study of abdominal angiographic scans in over 600 patients revealed the presence of trifurcation and quadrifurcation of CHA in 7.16% and 2.16% of the cases, respectively[9]. The MHA, which is rarely

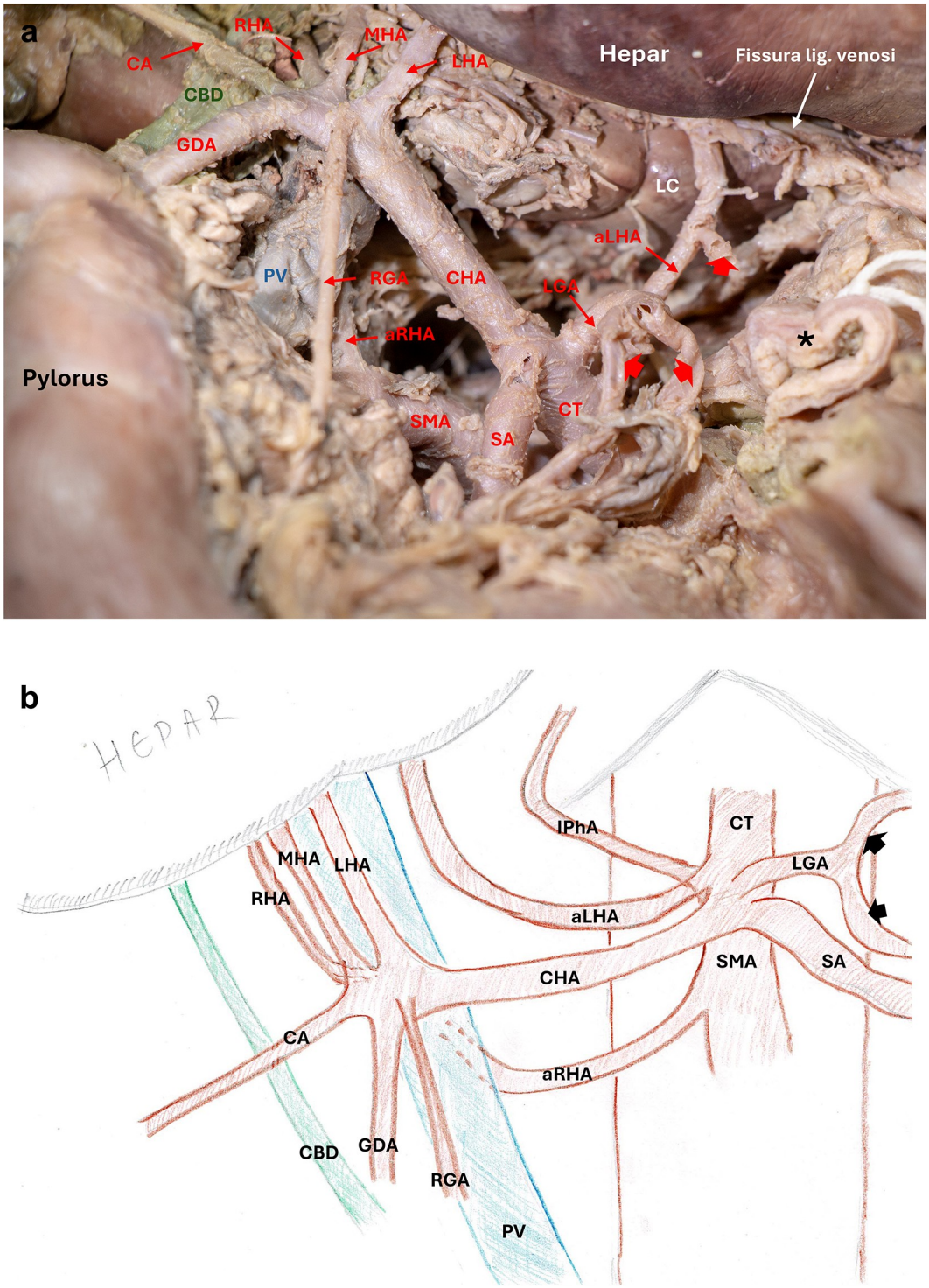

Figure 1. Photographs (a) and illustration (b) of the branches of the CT and the origin of the SMA from aorta. (a) Native state of the CT and its branches located in omentum minus and the origin of SMA from aorta. (b) Drawing presenting all branches of the CT and aRHA coming from the SMA. CT, coeliac trunk; CHA, common hepatic artery; LGA, left gastric artery; SA, splenic artery; aLHA, accessory left hepatic artery; LHA, left hepatic artery; MHA, middle hepatic artery; RHA, right hepatic artery; SMA, superior mesenteric artery; aRHA, accessory right hepatic artery; CA, cystic artery; GDA, gastroduodenal artery; RGA, right gastric artery; IPhA, inferior phrenic artery; PV, portal vein; CBD, common bile duct; LC, lobus caudatus. Tick arrows indicate gastric branches from LGA and aLHA. The asterisk points at the cardia of the stomach which is ligated, cut and removed to the left for better representation of the blood vessels in omentum minus.

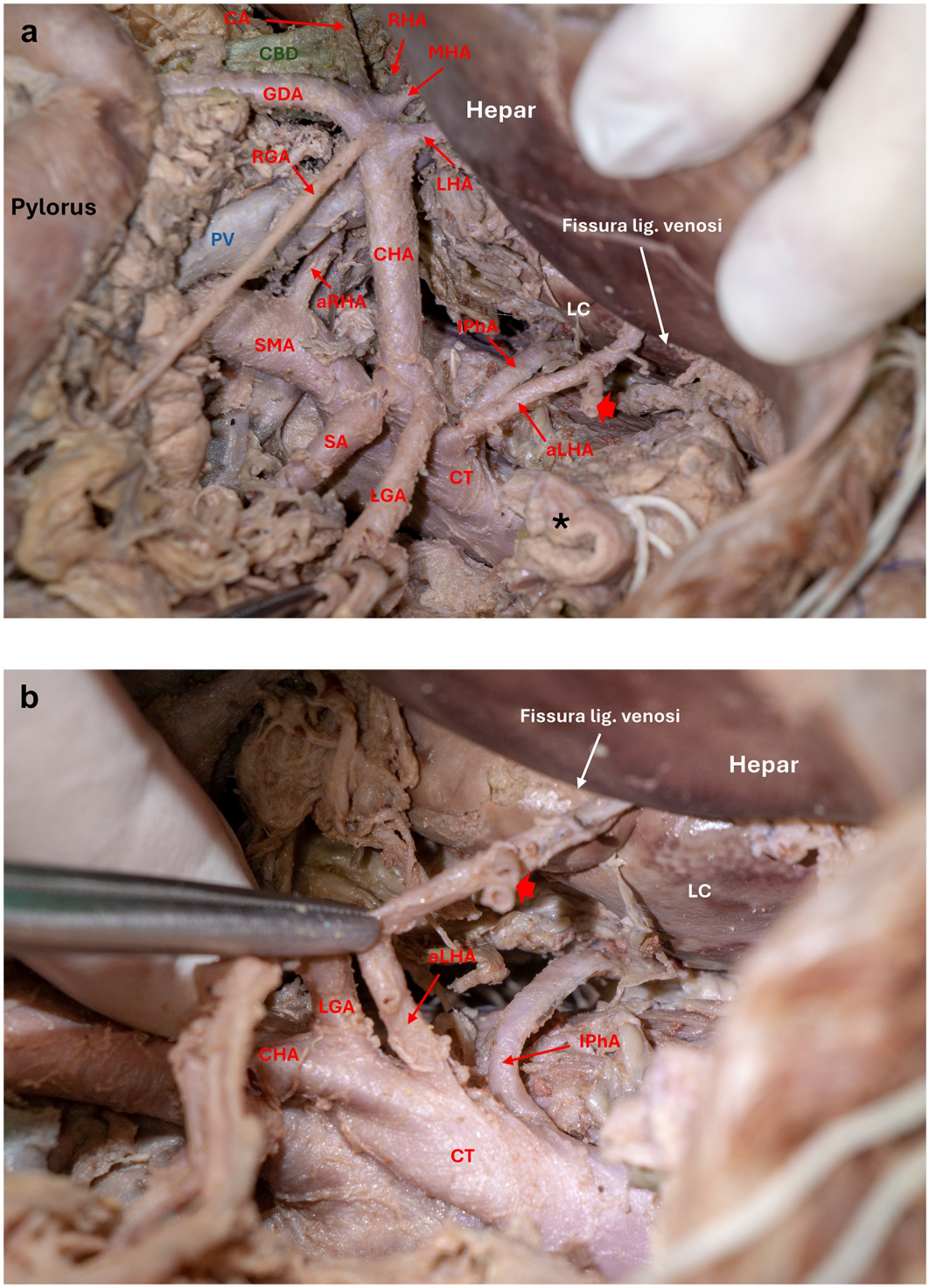

Figure 2. Photographs of the branches of the CT and the origin of the SMA from aorta. (a) The left lobe of the liver is lifted so that CT and its branches located in omentum minus and the origin of SMA with aRH Aare presented in more detail. (b) Close view of the origin of the right IPhA and aLHA from the CT. CT, coeliac trunk; CHA, common hepatic artery; LGA, left gastric artery; SA, splenic artery; aLHA, accessory left hepatic artery; LHA, left hepatic artery; MHA, middle hepatic artery; RHA, right hepatic artery; SMA, superior mesenteric artery; aRHA, accessory right hepatic artery; CA, cystic artery; GDA, gastroduodenal artery; RGA, right gastric artery; IPhA, inferior phrenic artery; PV, portal vein; CBD, common bile duct; LC, lobus caudatus. Tick arrow indicates gastric branches from aLHA. The asterisk points at the cardia of the stomach which is ligated, cut and removed to the left for better representation of the blood vessels in omentum minus.

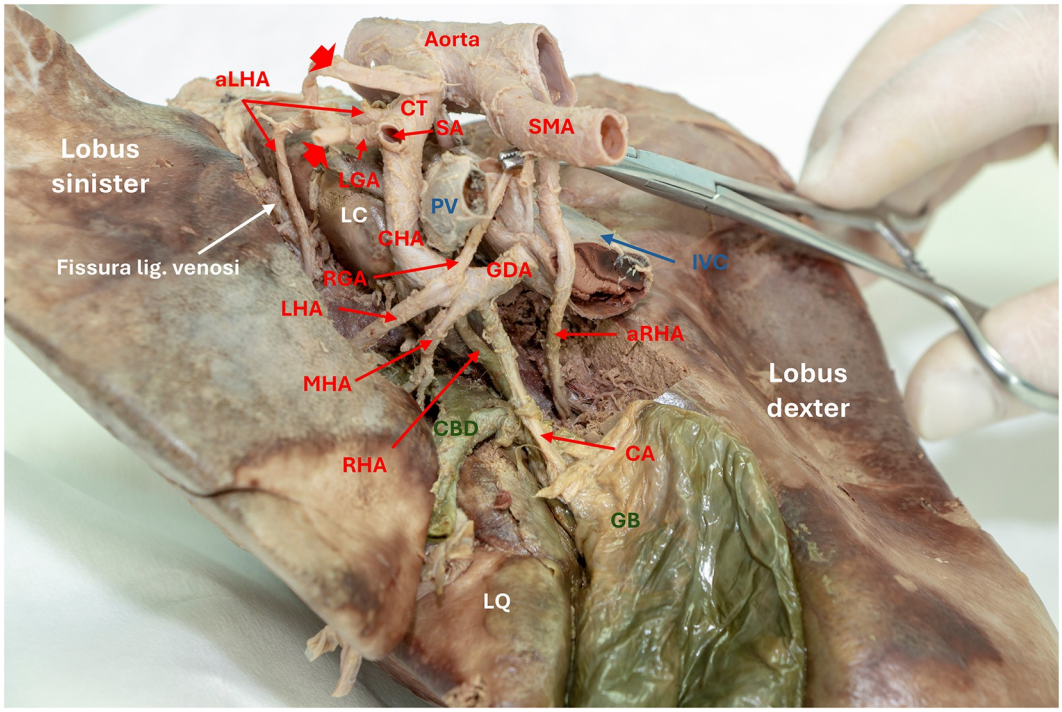

Figure 3. Photograph of the visceral surface of the liver showing the hepatic arteries and their topography. The RGA was pulled aside. CT, coeliac trunk; CHA, common hepatic artery; LGA, left gastric artery; SA, splenic artery; aLHA, accessory left hepatic artery; LHA, left hepatic artery; MHA, middle hepatic artery; RHA, right hepatic artery; SMA, superior mesenteric artery; aRHA, accessory right hepatic artery; CA, cystic artery; GDA, gastroduodenal artery; RGA, right gastric artery; PV, portal vein; IVC, inferior vena cava; GB, gall bladder; CBD, common bile duct; LC, lobus caudatus. Tick arrows indicate gastric branches from aLHA.

mentioned in anatomy and surgical textbooks, was defined by Michels[1] as the artery located in fissura umbilicalis that supplied segment IV (lobus quadratus) of the liver. In majority of the cases the MHA was arising from either LHA or RHA[10,11,14,15]. However, in around 2% of cases it originated from CHA and in 2%–4.8% from PHA[11,14,16].

The presence of aRHA was the most common variation of the hepatic artery with frequency of 15%–35%[2,8,10,17] and most

Table 1

Diameter and distance of origin of investigated arteries

Name of the artery	Diameter (mm)	Distance of origin (mm)	Implications for liver transplantation and tumor resection of variant arteries
Right inferior phrenic artery (IPhA)	2.3	1.4 mm from the origin of coeliac trunk (CT)	
Accessory left hepatic artery (aLHA)	2.1	11 mm from the origin of CT	Increased complexity of surgery.
Left gastric artery (LGA)	3.2	14.6 mm from the origin of CT	
Splenic artery (SA)	4.3	19.5 mm from the origin of CT	
Common hepatic artery (CHA)	4.8	19.5 mm from the origin of CT	In case of CHA pentafurcation into the LHA, MHA, RHA, CA, and RGA before origin of GDA, clamping or ligation of CHA can cause gastric or duodenal hypoperfusion.
Left hepatic artery (LHA)	2.3	23.9 mm from the origin of CHA from the CT	
Middle hepatic artery (MHA)	1.7	23.9 mm from the origin of CHA from the CT	
Right hepatic artery (RHA)	2.0	23.9 mm from the origin of CHA from the CT	
Cystic artery (CA)	1.7	23.9 mm from the origin of CHA from the CT	
Right gastric artery (RGA)	1.8	23.9 mm from the origin of CHA from the CT	
Gastroduodenal artery (GDA)	4.0	23.9 mm from the origin of CHA from the CT	
Accessory right hepatic artery (aRHA)	2.2	15.3 mm from the origin of the superior mesenteric artery (SMA)	Increased complexity of surgery. Excessive traction of the head of the pancreas during pancreatoduodenectomy could lead to thrombosis of aRHA coming from SMA.

often it branched from the SMA as in the presented case. The aLHA arises as a branch of the LGA in 5%–10% of the population[3,10,17] but in the presented case it was identified as a separate branch coming directly from the CT. Combined variation of aLHA and aRHA was present only in 0.27% of the population[17].

The presence of replaced and/or accessory LHA and RHA, and variations in the origin of the MHA are of significant importance during planning and execution of living donor liver transplantation[11]. During pancreatoduodenectomy the aRHA arising from SMA should be carefully dissected and excessive traction of the head of the pancreas should be avoided as it may cause thrombosis of the aRHA[17].

Development of the vasculature to the embryonic liver is a complicated process of angiogenesis and remodeling in which regression and annexation of vessels occur. Three principal arteries supply the liver during the early stages of embryonic development. The LHA from LGA supplies segment 2, an artery from the CT supplies segments 3, 4, 5, and 8 and RHA from SMA supplies segments 6 and 7. The arteries arising from LGA and SMA undergo regression, if they persist aberrant hepatic arteries result. The described variations would be a result in deviation from this process[5,11].

Conclusions

Single anomaly in the coeliac and mesenteric arterial systems is not rare. Such a complex combination, as the one presented in the current case, represents a significant deviation from the norm. These variations are of great clinical importance for surgeons and interventional radiologists to avoid iatrogenic vascular injuries during procedures such as Whipple surgery or liver transplantation. Visceral angiography, together with radiological imaging techniques such as multidetector computed tomography and magnetic resonance imaging, are very helpful and should play a key role in preoperative evaluation and planning.

Ethical approval

Ethical approval is not required for the case report in our institution, Medical University – Pleven. The cadaver was property of the Department of Anatomy, Histology, Cytology and Biology, Medical University – Pleven and all procedures complied with the ethical principles outlined in the Declaration of Helsinki of 1975 (revised 2013; https://www.wma.net/policies-post/wmadeclaration-of-helsinki-ethical-principles-for-medical-research-involving-human-subjects/).

Consent

Written informed consent was obtained from the patient next of kin for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

Conflicts of interest disclosure

The authors declare no conflicts of interest.

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Author's contribution

Conceptualization: S.T.; data acquisition: S.T. and M.D.; data analysis or interpretation: S.T., M.D., P.H., and I.B.-T.; writing – original draft preparation: S.T. and I.B.-T.; writing – review and editing: S.T., M.D., P.H., and I.B.-T.; visualization: S.T. and M.D.; supervision: S.T. and P.H.; project administration: S.T. All authors have read and agreed to the published version of the manuscript.

Research registration unique identifying number (UIN)

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Paper was not invited.

Data availability statement

Data are contained within the article.

Assistance with the study

Not invited.

Presentation

Not invited.

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