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Case Report

Anatomy Section

Pentafurcation of Coeliac Trunk with Accessory Hepatic Arteries and Replaced Middle Colic Artery: A Cadaveric Case Report

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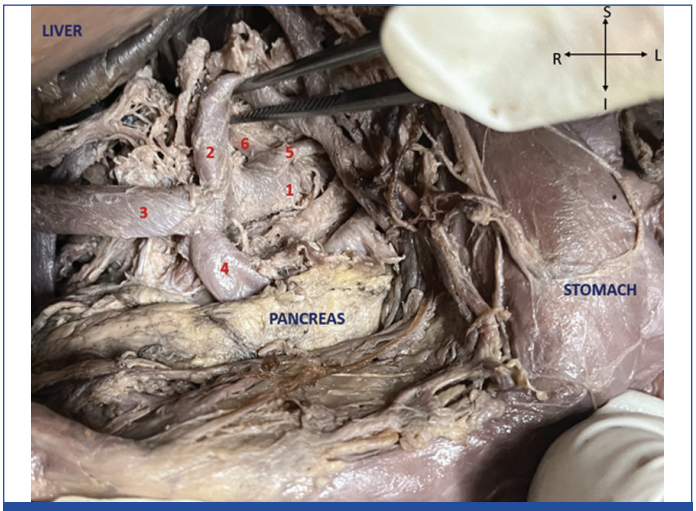
ABSTRACT

The present report documents a rare case of Coeliac Trunk (CT) pentafurcation identified during routine cadaveric dissection in a male cadaver of approximately 60 years of age, with the CT giving rise to five distinct branches: the Left Gastric Artery (LGA), Common Hepatic Artery (CHA), Splenic Artery (SA), and both the Right and Left Inferior Phrenic Arteries (RIPA and LIPA). Additional notable arterial variations included the presence of accessory left and right hepatic arteries, as well as a replaced Middle Colic Artery (rMCA) originating from the SA, deviating from classical vascular anatomy. Such complex configurations carry significant clinical implications for hepatobiliary, pancreatic, and gastrointestinal surgery, where unexpected vascular routes can affect organ perfusion and complicate surgical intervention. Recognition of accessory hepatic and cystic arteries is particularly vital in procedures involving the porta hepatis and gallbladder, while aberrant mesenteric branching necessitates careful planning during colonic and pancreatic resections. Preoperative detection of these anomalies using advanced imaging modalities is crucial to mitigating intraoperative risks, preventing ischaemic complications, and optimising outcomes in transplantation and oncologic surgery. The present case underscores the necessity for heightened anatomical awareness and individualised operative strategies in the presence of rare vascular variants, thereby serving as a valuable reference for clinicians and anatomists striving for excellence in patient safety and surgical precision.

Keywords: Common hepatic artery, Complex configuration, Double cystic artery, Splenic artery

CASE REPORT

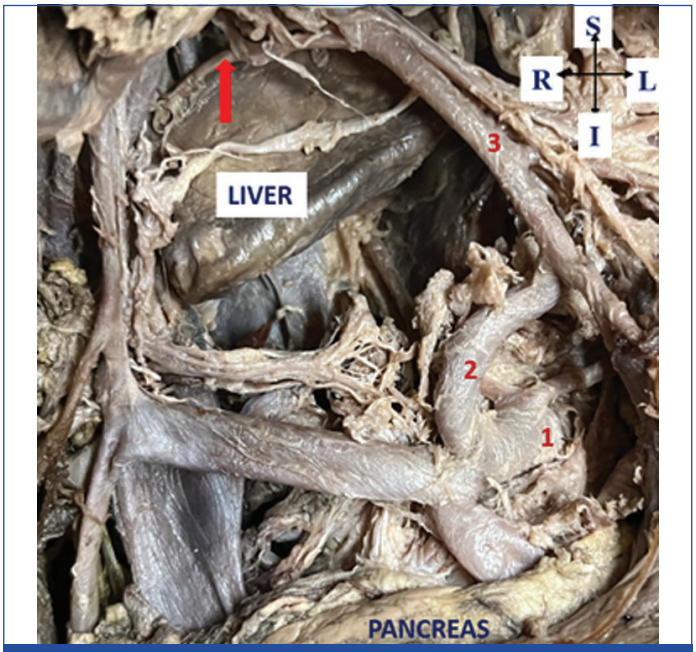
During routine dissection of a male cadaver of approximately 60 years of age for teaching purposes, several vascular variations were observed. The CT originated from the anterior surface of the abdominal aorta at the level of T12. Five branches were seen arising from the CT, namely the LGA, CHA, SA, and the RIPA and LIPA [Table/Fig-1].



[Table/Fig-1]: Pentafurcation of coeliac trunk: 1) Coeliac trunk; 2) Left Gastric Artery (LGA); 3) Common hepatic artery; 4) Splenic artery; 5) Left Inferior Phrenic Artery (LIPA); 6) Right Inferior Phrenic Artery (RIPA).

The LGA originated from the CT and gave rise to an accessory Left Hepatic Artery (aLHA), which entered the porta hepatis separately. A branch emerging from the aLHA supplied the caudate lobe of the liver independently [Table/Fig-2]. The LGA then descended along the lesser curvature of the stomach and terminated by anastomosing with the right gastric artery.

The CHA followed a short, straight course to the right and then terminated by dividing into the gastroduodenal and proper hepatic

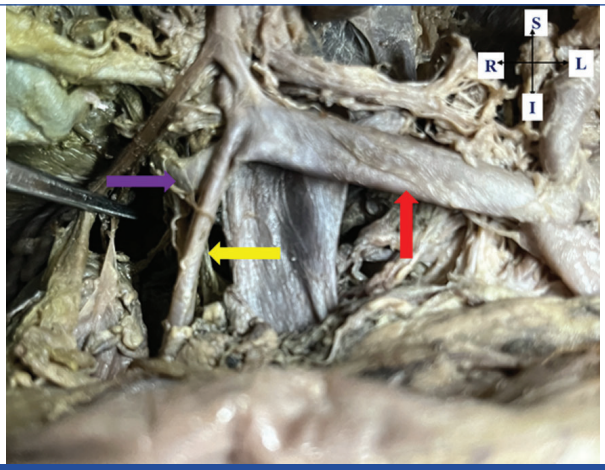


[Table/Fig-2]: Accessory Left Hepatic Artery (aLHA) arising from Left Gastric Artery (LGA): 1) Coeliac Trunk (CT); 2) Left Gastric Artery (LGA); 3) aLHA; Red Arrow-Branch from aLHA to caudate lobe of liver.

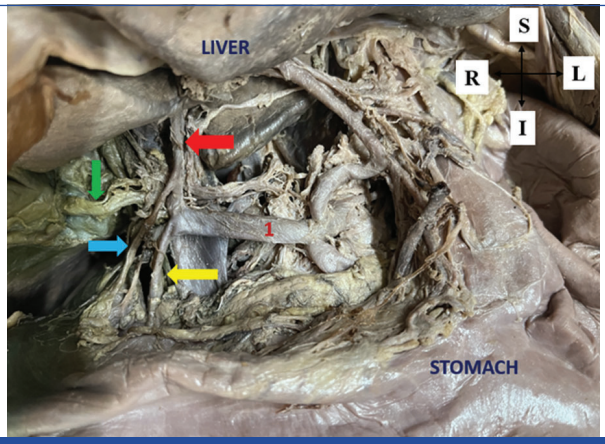
arteries. The gastroduodenal artery descended posterior to the first part of the duodenum, after which it continued as the right gastroepiploic artery. No superior pancreaticoduodenal artery was observed arising from the gastroduodenal artery [Table/Fig-3].

An accessory Right Hepatic Artery (aRHA) was seen originating from the right side of the gastroduodenal artery, posterior to the first part of the duodenum. After its origin, the aRHA ascended and entered the porta hepatis separately. The aRHA also gave rise to an accessory Cystic Artery (aCA) that supplied the gallbladder. This aCA, arising from the aRHA, formed Calot's triangle together with the cystic duct and the common hepatic duct. The proper hepatic

artery arising from the CHA was found to be smaller in diameter than both the aRHA and aLHA. The proper hepatic artery gave rise to the right gastric artery and the cystic artery [Table/Fig-4].

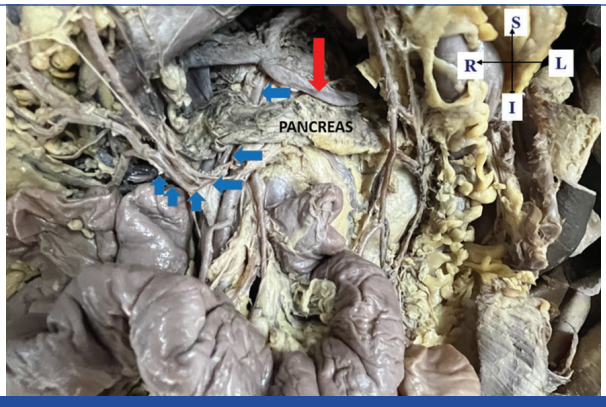


[Table/Fig-3]: Accessory Right Hepatic Artery (aRHA) arising from Gastroduodenal Artery. Absence of superior pancreaticoduodenal artery arising from gastroduodenal artery. Red Arrow- Common Hepatic Artery, Yellow Arrow- Gastroduodenal artery, Purple Arrow- Accessory Right Hepatic Artery (aRHA).



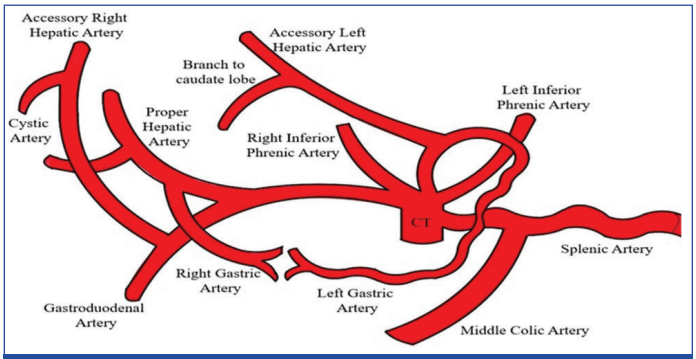
[Table/Fig-4]: Branches from proper hepatic artery: 1) Common hepatic artery, Red arrow - Proper hepatic artery, Yellow arrow - Gastroduodenal artery, Blue arrow - Right gastric artery from proper hepatic artery, Green arrow - Cystic artery from proper hepatic artery.

The SA, after originating from the CT, coursed inferiorly and to the left along the posterosuperior surface of the body of the pancreas. Another branch was observed arising from the SA, which travelled inferiorly, posterior to the body of the pancreas and anterior to the uncinate process. This branch entered the transverse mesocolon, supplied the transverse colon, and terminated by anastomosing with the right and left colic arteries. The usual MCA originating from the SMA was absent in this case. Thus, this rMCA arose from the SA [Table/Fig-5]. The SA then gave off the left gastroepiploic artery and short gastric arteries and subsequently entered the hilum of the spleen.



[Table/Fig-5]: Replaced Middle Colic Artery (rMCA) arising from SA. Red Arrow- Splenic Artery (SA), Blue Arrows - Middle Colic artery (MCA).

The RIPA and LIPA arose from the CT and coursed superolaterally to reach the undersurface of the diaphragm. The superior suprarenal artery was given off from these inferior phrenic arteries. All the aforementioned variations are represented schematically in [Table/Fig-6].



[Table/Fig-6]: Schematic diagram representing all the variations in the present report.

DISCUSSION

The CT is chiefly recognised for its trifurcation into the LGA, SA, and CHA. However, extensive anatomical variability has been reported, with pentafurcation representing a particularly rare configuration. Pentafurcation, where the CT divides into five branches, has been documented in only 12.9% of cadaveric cases in select studies and remains an unusual finding during preoperative imaging or surgical exploration [1].

Variations in the branching pattern of the CT were first classified by Adachi B, whose classification does not include either pentafurcation or the origin of the inferior phrenic arteries from the CT [2]. In a study by Dillibabu E and Prabakaran M, a newer classification system for CT variations was proposed based on embryological correlations. According to their classification, the pentafurcation reported in the present study corresponds to Type VId [3].

This branching complexity is rooted in embryological development, wherein the ventral splanchnic (vitelline) arteries form intricate anastomoses, occasionally resulting in the persistence or regression of atypical vascular channels. Such variability may produce additional branches such as diaphragmatic arteries and, in rare cases, accessory hepatic arteries [4]. The vascular variations identified in the present case warrant evaluation of the following aspects:

Accessory Left Hepatic Artery (aLHA) from the Left Gastric Artery (LGA): An accessory LHA arising from the LGA is well recognised and is categorised as type V in Michels NA's classification and type II in Hiatt JR et al., classification, both of which are internationally accepted [5,6].

Osman B et al., reported two cases of a replaced RHA arising directly from the CT. In their second case, the CT exhibited quadrifurcation into the LGA, replaced RHA, CHA, and SA, with an aLHA originating from the LGA [7]. Although their branching pattern differs from the present observation of pentafurcation, the finding of an aLHA from the LGA closely parallels one of the key features in the current case.

In a series of 152 patients, Zagyapan R et al., identified classical CT trifurcation in 62.5% of individuals. They classified left hepatic arteries arising from the LGA as type III variants, with a frequency of 13.1%. This aligns well with the aLHA documented in the present dissection. However, their classification, based on Vandamme and Bonte, considered the inferior phrenic arteries to be collateral branches rather than principal terminal branches [8], which contrasts with the direct origin of these arteries observed in the present pentafurcation.

Mazurek A et al., described a cadaveric case in which the LGA arose directly from the abdominal aorta, giving rise to both the RIPA and an aLHA. They further reported a prevalence of 8.2%

for an aLHA originating from the LGA, closely aligning with the variation observed in the present case [9]. While their findings involved a hepatosplenic trunk arising from the aorta rather than a pentafurcated CT, the combination of an aLHA from the LGA and the involvement of inferior phrenic arteries remains highly relevant to the current anatomical variation.

The report by Covantev S et al., provides perhaps the closest parallel to the present finding. They documented a CT branching into five vessels: the SA, CHA, LGA, LIPA, and a short trunk that subsequently gave rise to the RIPA and an aRHA. Additionally, an aLHA originated from the LGA [4]. This rare combination of five branches, inclusive of the phrenic arteries and an aLHA, closely mirrors the anatomical configuration encountered in the present case.

Further supporting evidence is provided by Thangarajah A and Parthasarathy R, who evaluated CT and hepatic artery variations using MDCT angiography in a South Indian cohort. They found a normal CT in 89.5% of cases but identified Type V variation (aLHA from the LGA) as the most common hepatic arterial anomaly, with a prevalence of 8.5% [10]. This strongly corroborates the presence of an aLHA from the LGA in the present dissection, although their study did not identify pentafurcation involving inferior phrenic arteries.

Accessory Right Hepatic Artery (aRHA): Comparative data from studies on CA variations similarly emphasise the wide diversity in arterial origins and branching. These include accessory branches from the RHA, hepatic artery proper, aRHA, and superior mesenteric artery, occasionally presenting as compound or double cystic arteries [11]. Such variability reflects the multiplicity and complexity observed in the current case.

The present dissection identified an aRHA originating from the gastroduodenal artery, a rare variant previously noted by Yamaguchi T et al., who reported it in 3.5% of patients. They underscored its clinical significance during pancreaticoduodenectomy, where inadvertent ligation may compromise hepatic perfusion. Accordingly, they advocated for detailed preoperative imaging and intraoperative Doppler evaluation to mitigate surgical risks [12].

A comparable pattern was also reported by Dolenšek J, who described triple hepatic inflows supplied by accessory hepatic arteries from the LGA and superior mesenteric artery, alongside double cystic arteries from an aRHA [13]. The arterial supply documented in the present case, involving multiple hepatic inflows, aligns with such complex embryological persistence.

Natsis K et al., documented an anomaly characterised by an extensive anastomosis between the CHA and gastroduodenal artery, an aRHA from the superior mesenteric artery, and the absence of a proper hepatic artery [14]. The branching configuration in the present case, including accessory inflows entering the porta hepatis and unique caudate lobe supply, shows a strong resemblance to such rare vascular reorganisations.

Comparable clinical significance is echoed in the series reported by Pueyo-Périz EM et al., who described a replaced RHA arising from the gastroduodenal artery. They stressed the risks posed during pancreatic and hepatic resections, where routine ligation of the gastroduodenal artery may jeopardise hepatic blood flow [15]. This directly reflects the anatomical considerations presented in the current case, reinforcing the importance of meticulous preoperative vascular mapping.

The combined occurrence of an aRHA from the gastroduodenal artery and an aLHA from the LGA, as documented in the present dissection, represents a rare but clinically significant vascular constellation. Previous clinical reports have emphasised that preserving such anomalous vessels during oncologic resections is feasible when advanced imaging facilitates accurate preoperative identification, thereby ensuring hepatic perfusion is maintained.

Middle Colic Artery (MCA): Karitnig R et al., described another rare anomaly involving an MCA originating from the SA, accompanied by a replaced RHA (Michel's Type III) [16]. Although this configuration differs from the present pentafurcation, it highlights the remarkable diversity of mesenteric and hepatic arterial arrangements, providing a valuable framework for comparison.

Kwong MLM and Pelton J reported a rare case of an MCA arising from the gastroduodenal artery during pancreaticoduodenectomy. While their analysis primarily contextualised this variation within hepatic artery classifications, the described MCA origin underscores the potential for highly unusual mesenteric branching patterns, even though it does not directly correspond to the pentafurcation observed in the present case [17].

Inferior Phrenic Arteries (IPA): Shefna M and Das L studied IPA origins in cadaveric specimens, reporting that the RIPA arose from the coeliac trunk in 36% of cases and the LIPA in 29% [18]. These findings strongly support the present observation of both inferior phrenic arteries originating directly from the coeliac trunk.

Kumar Vd et al., proposed a detailed classification of IPA variations using CT angiography, in which Type IIC specifically describes both RIPA and LIPA arising directly from the coeliac trunk, with a prevalence of 13.2% [19]. This closely corroborates the pentafurcated branching pattern seen in the current case. Similarly, Aslaner R et al., demonstrated that a considerable proportion of RIPAs (40.3%) and LIPAs (25.2%) originated directly from the coeliac axis, further validating the anatomical variation described here [20].

Cadaveric data from Hemamalini highlighted rare patterns, including the LIPA arising directly from the coeliac trunk, which, while not encompassing both phrenic arteries as in the current case, nonetheless supports the broader spectrum of coeliac trunk variation [21].

Sheta AA reported quadrifurcation of the coeliac trunk in 0.51% of patients and direct IPA origin in 2.05%, alongside an aLHA from the LGA in 5.65% [22]. Both findings substantiate distinct components of the present case, particularly the contribution of IPAs to coeliac trunk branching.

Mahajan A et al., documented a cadaveric case where the CT gave rise to the LIPA, hepatogastric trunk, SA, and CHA, which they classified as Michels' Type IV [23]. While their branching pattern differs, the direct origin of the LIPA from the coeliac trunk provides a valuable comparison.

Finally, Pinal-Garcia DF et al., reported trifurcation of the coeliac trunk in 43.6% of cases but identified additional branches in 47.9%, with pentafurcation observed in 12.9%. Importantly, they noted that one or both IPAs originated from the coeliac trunk in 41.4% of dissections, with separate origins of both RIPA and LIPA from the coeliac trunk in 13.6% [1]. These findings strongly corroborate the present case of pentafurcation, in which both inferior phrenic arteries arise directly from the coeliac trunk.

CONCLUSION(S)

The pentafurcation of the coeliac trunk, as observed in this case, exemplifies the remarkable spectrum of arterial variation that may be encountered in clinical and surgical practice. Awareness of such atypical branching-particularly the origin of accessory hepatic arteries, inferior phrenic arteries, and a replaced MCA-has profound implications for hepatobiliary and gastrointestinal surgery, organ transplantation, and advanced oncologic resections. Accurate preoperative identification of these vascular anomalies via high-resolution imaging is paramount to prevent inadvertent ligation or injury, which could compromise hepatic or diaphragmatic perfusion and lead to significant postoperative morbidity. Similarly, knowledge of replaced mesenteric branches, such as an MCA arising from the SA, is crucial to optimise bowel resection and anastomosis, and to avoid ischaemic complications.

The recognition of both inferior phrenic arteries originating from the coeliac trunk further supports the requirement for tailored surgical approaches in interventions for hepatic malignancy or transplant procedures. Ultimately, the pentafurcation variant reinforces the importance of anatomical vigilance and individualised surgical planning, serving as a vital reference for clinicians and anatomists confronted with rare but clinically impactful vascular patterns.

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