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Case Report

Anatomical Variations in the Branching Pattern of the Celiac Trunk, Number of Originating Arteries and Position of the Kidneys: A Cadaveric Dissection Report

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Abstract

According to anatomical reference books, the celiac trunk (CT) is divided into three terminal branches, namely the common hepatic artery (CHA), left gastric artery (LGA), and splenic artery (SA). However, variations in the number and location of the CT branches are possible. The body of a 40-year-old deceased male was used for anatomization in the Anatomical Hall of Alborz University of Medical Sciences (Karaj, Iran). During the dissection, variations in the branching pattern of the CT, such as the orientation of the main celiac branches, the origin of the inferior phrenic artery, and the aberrant supplementary artery to supply the liver were observed. Furthermore, a variation in the location of the kidneys and renal arteries was observed. In addition to CHA, LGA, and SA, two additional branching patterns, namely the left inferior phrenic artery (LIPA), and right accessory hepatic artery (RAHA) were noticed. This variation is rarely observed in human anatomy. Therefore, awareness of the arterial anatomy and possible variations is essential during surgeries (e.g., biliary tract surgery, liver transplant) and radiological procedures. To the best of our knowledge, such variations in the branching pattern of the CT have not been reported or described in anatomical reference books. Hence, the present study aimed to highlight the existence of these variations to assist surgeons, radiologists, and anatomists.

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Keywords ● Abdominal aorta ● Celiac artery ● Kidney ● Renal artery ● Variation

What's Known

- According to anatomical reference books, there are normally three branching arteries from the celiac trunk (CT), namely the common hepatic artery (CHA), left gastric artery (LGA), and splenic artery (SA). In addition, the left kidney is usually located at a higher position in relation to the right kidney.

What's New

- A rare variation of the branching pattern of the CT was observed. The CT is divided into five branches, namely CHA, LGA, SA, left inferior phrenic artery (LIPA), and right accessory hepatic artery (RAHA).
- The location of the right kidney was observed to be higher relative to the left kidney.

Introduction

The abdominal aorta originates from the aortic hiatus of the diaphragm, anterior to the twelfth thoracic vertebra, and descends anterior to the lumbar vertebrae.[1] The celiac trunk (CT) is the first unpaired anterior visceral branch of the abdominal aorta and arises just below the diaphragmatic aortic hiatus that supplies the foregut, usually at the level of T12 to the L1 vertebral body. The distance between CT and the aortic hiatus varies from 11.5 to 12.5 mm.[1] Variations in the branching pattern of CT, depending on the number of arising arteries, are categorized as bifurcation,

trifurcation, quadrifurcation, pentafurcation, hexafurcation, and agenesis.[2] The CT is 1-3 cm long and passes almost horizontally (anterolateral) forward, posterior to the lesser sac, and slightly to the right above the body of the pancreas and splenic vein. It then immediately bifurcates into the CHA and SA, where the LGA often originates from it. The distance between the origin of CT and the superior mesenteric artery (SMA) is 1-2 cm, and between SMA, and the origin of the inferior mesenteric artery (IMA) is 4-8 cm. IMA originates 3-4 cm above the aortic bifurcation at the L4 level.[3]

Inferior phrenic arteries (IPAs) are the first paired arterial branches of the abdominal aorta which give off small branches to the diaphragm, liver, adrenal gland, esophagus, stomach, inferior vena cava (IVC), and retroperitoneal. The right inferior phrenic artery (RIPA) and the left inferior phrenic artery (LIPA) generally originate from the aorta independently or as a common trunk. IPAs emerge between the diaphragm and renal arteries (RAs).[4] RAs originate from the lateral aspect of the abdominal aorta, just below the origin of the SMA at the L1-L2 vertebral level. In addition, liver is usually located under the right dome of the diaphragm, above the right kidney, and moves the right kidney farther from the left kidney such that the right renal artery (RRA) settles at a lower level from the left renal artery (LRA).[3]

In view of the above, one should be aware that other rare variations in the branching pattern of CT, the arteries originating from it, and the location of the kidneys exist, which are not described in the anatomical reference books. Hence, the present study aimed to highlight the presence of these variations to assist surgeons, radiologists, and anatomists.

Case Presentation

In March 2021, the body of a 40-year-old deceased male was used for anatomization in the Anatomical Hall of Alborz University of Medical Sciences, Karaj, Iran. The individual died following accidental high-voltage electrical burns. Permission were given by the individual to donate his body after death to medical colleges for medical education and research purpose.

After parasagittal incision and reflection of the abdominal wall, we identified the greater omentum and abdominal viscera including intestinal coils, transverse colon, and pancreas.

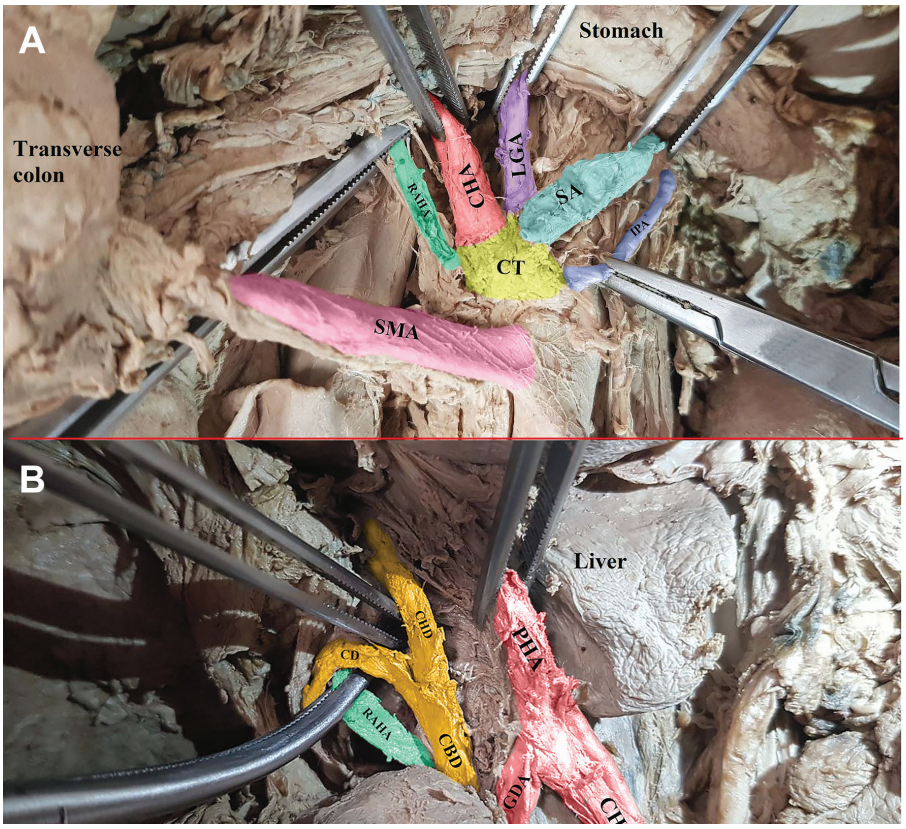

Figure 1: Special pattern of the celiac trunk (CT) and accessory hepatic artery is shown. (A) The CT in special pattern pentafurcates to the inferior phrenic artery (IPA), splenic artery (SA), left gastric artery (LGA), common hepatic artery (CHA), and right accessory hepatic artery (RAHA). The superior mesenteric artery originates from the abdominal aorta, slightly lower than the CT origin. (B) Accessory hepatic artery ascends behind the bile duct to provide blood supply to the liver. GDA: Gastroduodenal artery; PHA: Proper hepatic artery; CBD: Common bile duct; CHD: Common hepatic duct; CD: Cystic duct

However, contrary to expectations, the CT was observed at the inferior border of the pancreas. Beyond the CT, despite the classic solitary appearance of the celiac artery, we identified three main ascending celiac branches located posteriorly to the pancreatic body (figure 1). We also observed that LIPA originated from the base of CT and was directed to the dorsal surface of the pancreas. It then continued cranially towards the terminal part of the left hepatic lobe and reached the bare area of the inferior surface of the diaphragm (figure 2). Furthermore, the RAHA that provides blood supply to the liver originated from the right side of the CT and ascended cranially to settle in the hepatic triad behind the bile duct (figure 1). Surprisingly, the RRA originated from a higher level of the lateral side of the aorta than the LRA. In addition, the location of the right kidney was observed to be higher relative to the left kidney (figure 3).

Discussion

The findings of the present study demonstrated that the origin of the main branches of the CT (LGA, CHA, and SA) did not correspond to the normal solitary appearance. It was observed that two additional arteries originated from the CT, namely LIPA, which originated from the left side of the CT base, and the RAHA from the right side of the CT to provide blood supply to the liver. Given the variation and anomalies of hepatic arteries, it is essential that surgeons be aware of such variations. We also observed that the location of the right kidney was higher in relation to the left kidney. As mentioned earlier, the distance between CT and the origin of SMA is normally 1-2 cm, between SMA and IMA is 4-8 cm, and between IMA and aortic bifurcation is 3-4 cm. Measurement of these distances confirmed no variations in the origin of visceral branches. However, the pancreas was located

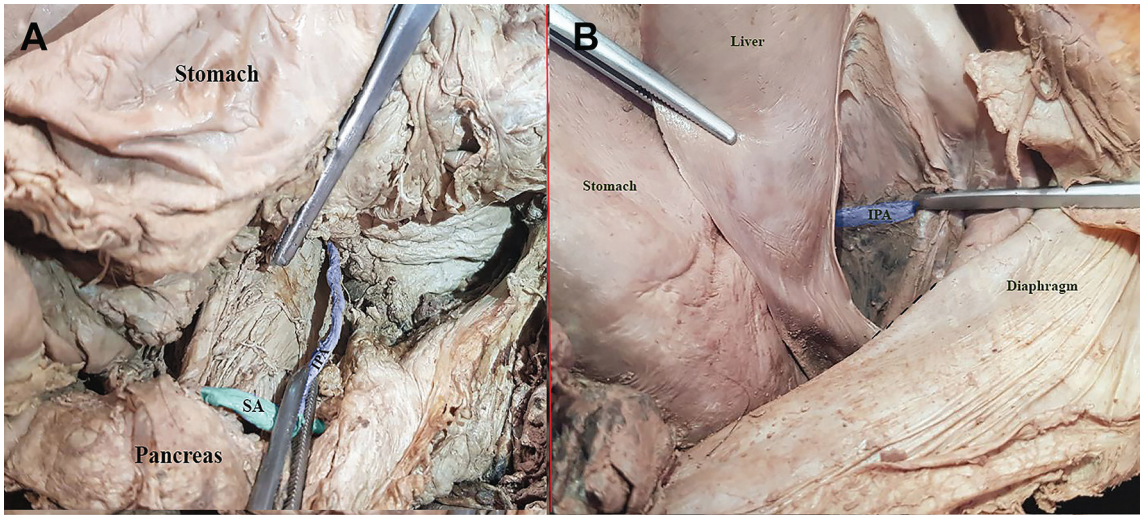

Figure 2: The pathway of the inferior phrenic artery is shown. (A) The inferior phrenic artery (IPA) ascends behind the pancreas and the splenic artery (SA). (B) The IPA continues its pathway and ascends behind the stomach and passes to the terminal part of the left lobe of the liver.

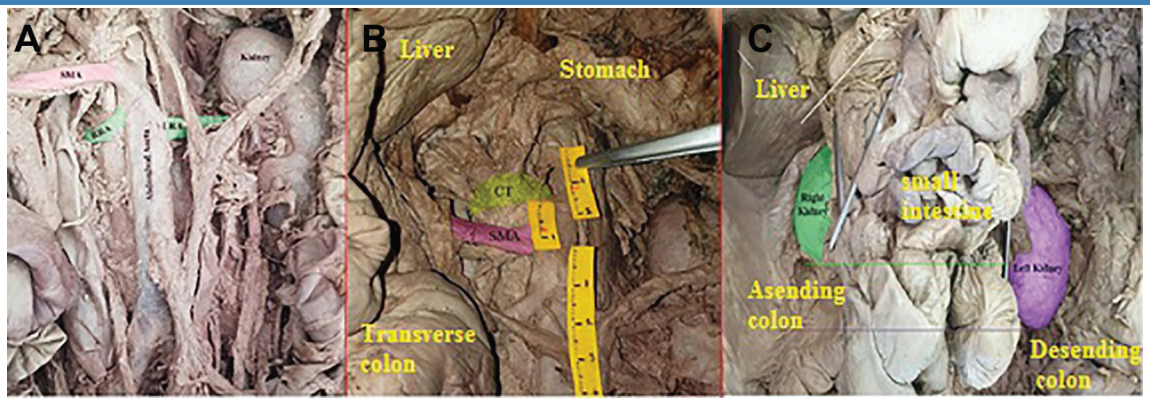

Figure 3: Positional variation of kidneys and their arteries is shown. (A) Renal arteries, slightly lower than the origin of the superior mesenteric artery (SMA), were branched from the abdominal aorta but the right renal artery (RRA) were originated from the abdominal aorta to a higher position than the left renal artery (LRA). (B) The distance between the celiac trunk (CT) and aortic hiatus was 1.2 cm, between the CT and SMA was 0.7 cm, between SMA and IMA was 5.2 cm, and between IMA and aortic bifurcation was 3.7 cm. (C) Inferior pole of the left kidney is higher than the inferior pole of the right kidney.

higher relative to its normal position.

During fetal development, CT and IPA are derived from six pairs of ventral splanchnic branches. These branches degenerate during growth, however, the persistence of longitudinal channels between these primitive vessels may lead to vascular variations. IPA is said to be formed by the persistent superior artery of irregular series of arterial vessels called Rete arteriosus urogenital.[5] Although the classification of common variants is important and elementary, knowledge of rare variations identified during single observations is also needed, because many vascular variants are usually asymptomatic. Consequently, awareness of even such rare CT variations by general surgeons, transplant surgeons, and radiologists is essential.[5]

Computed tomography findings showed five branches of the CT in 2-5% of cases. In addition to the three normal branches, two more arteries – a common trunk of the inferior phrenic artery (CIPA) and a middle colic artery – were reported to originate from the CT.[6] This pattern cannot be classified as the pentafurcation of the CT,[2] since the defined five branches are LGA, CHA, SA, LIPA, and RAHA. Reda and colleagues showed that in 40% of cases, the CHA and SA are separated from the CT by a common trunk.[7] Another study identified CHA in the lesser omentum and three LGAs originating from the CHA.[8]

Variations in the origin of IPAs are very common. LIPA and RIPA can arise separately from the same or different origin or by a common stalk. Gokan and colleagues found that in 46% of cases, RIPA originated from the aorta and in 52% from the left side of the CT.[9] They also stated an alternative origin (left gastric, hepatic, superior mesenteric, and spermatic), however, these occur with a frequency of less than 4% on either the right or left side of the CT. Pulakunta and colleagues studied 32 cadavers and observed that IPAs originated from the CT in two cases (6.25%), one from the LGA (3.125%), and one from the RAA (3.125%).[10] In another study of 68 cadavers, the origin of IPA in most cases was from the aorta (61.6%) and originated from either renal, left gastric, or middle adrenal arteries.[11] IPA arose from the aorta in 53.125%, CT in 28.125%, renal artery in 15.625%, and SMA in 3.125% of the 32 cadavers. The RIPA arose from the aorta in 56.25%, CT in 18.75%, renal artery in 18.75%, and SMA in 6.25% of the cases. The LIPA arose from the aorta in 50%, from CT in 37.5%, and the rest (12.5%) originated from the renal artery. The IPA usually originates between the middle of the 12th thoracic and second lumbar vertebrae. The RIPA and LIPA originate with almost equal frequency from the aorta and celiac axis. They arise with less frequency from the renal arteries.[11]

In our case, one of the five CT branches was the RAHA, which occurs in 2% of cases. Variation in the liver arterial supply is relatively common, and aberrant hepatic arterial anatomy is found in 41% of the population. If the right or left hepatic arteries are not atrophied, they exist in adults as RAHA and LAHA, respectively. However, if RAHA is present, it mainly originates from the SMA (5%).

We observed that the RRA and the right kidney were located in a higher position relative to the LRA and the left kidney, respectively. The origin of the RA can vary from level T12 to L4. Although the right kidney is more caudally to the left kidney, the RRA is cephalic to the LRA. According to the atlas of anatomy by Rohen, the RRA is longer and often higher, passes posterior to the IVC, and can originate from a higher position than the LRA. Two possibilities could be considered for the higher location of the right kidney in relation to the left kidney. First, the right kidney was ascended to a higher location relative to its normal position. Second, during embryonic development, the left kidney was not ascended sufficiently to reach its normal position.

Conclusion

In the present case, the celiac trunk was divided into five branches, namely the left inferior phrenic artery, splenic artery, left gastric artery, common hepatic artery, and right accessory hepatic artery. In addition, the location of the right kidney was higher relative to the left kidney.

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Authors' Contribution

M.D, F.M, A.Sh, A.K, M.B, S.M: Conception, design of the work, data acquisition, analysis, drafting, and revising it critically. All authors have read and approved the final manuscript and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Conflict of Interest: None declared.

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