Variant anatomy of the coeliac trunk – Review of literature with a case report

Dandekar UK* and Dandekar KN

SMBT Institute of Medical Sciences and research Centre, Dhamangaon Taluka- Igatpuri Dist- Nasik (Maharashtra) India PIN-422403

*Correspondence Info:
Dr. Dandekar Usha K.
Assistant Professor,
Department of Anatomy
SMBT Institute of Medical Sciences and Research Centre,
Nandi Hills, Dhamangaon Taluka- Igatpuri Dist- Nasik (Maharashtra) India PIN-422403
E-mail: drushadandekar@yahoo.co.in

Abstract

Variations of arteries in the abdomen frequently include the coeliac, renal and gonadal arteries. These anatomic variations are often responsible for variety of clinical conditions and pose major considerations during surgeries. Thorough knowledge of normal and variant anatomy of major unpaired arteries originating from the abdominal aorta is necessary to accomplish successful abdominal operations and to avoid complications. During routine dissection we came across a variation in the coeliac trunk. Instead of normal trifurcation of the coeliac trunk, we observed three separate trunks arising from the abdominal aorta: gastrophrenic trunk, hepatosplenic trunk and hepatophrenic trunk. The incidence and developmental as well as clinical significance of these variations having crucial surgical importance are discussed with a detailed review of the literature.

Keywords: Coeliac trunk, Coeliac trunk variations

1. Introduction

The coeliac artery, commonly known as the coeliac trunk (CT), is a major visceral branch of the abdominal aorta originating at its anterior contour just below the aortic hiatus of diaphragm at the level of T12- L1 vertebral bodies. It is about 1.5-2 cm long and 6-8 mm in diameter. It passes almost horizontally forward and divides into 3 branches – left gastric, splenic and common hepatic arteries1,2. The most common form of the CT is tripodal. According to Michels, this tripodal form occurs in 55% of individual3. Van Damme and Bonte reported that this form occurs in 86% of individuals4. The trifurcation of CT was first described by Haller in 1756. This “Tripus Halleri” is still considered to be the normal appearance of the CT4-11, although many variational patterns of the CT have been described. It appears that only 87.6% of the CT exhibited the classical trifurcation, while an incomplete CT accounted for 12.2% and absence of the CT was extremely rare8. Anatomical variations in the branching pattern of the CT are of considerable importance in liver transplants, laparoscopic surgery, radiological abdominal interventions and penetrating injuries to the abdomen. Knowledge of these variations is important for proper preoperative diagnosis and planning of surgical and radiological procedures.

The aim of this review is to emphasize the importance of variation of the CT in previously reported cases in literature to discuss the incidence and its developmental significance and to report a case which prompted this review.

2. Case report

During routine dissection of the posterior abdominal wall, we observed anomalous branching pattern of the CT in a 50 yr old male cadaver. The CT and its branches were carefully dissected and the surrounding structures were delineated. The classical trifurcation of the CT was absent; instead three separate trunks were seen: gastrophrenic, hepatosplenic and hepatophrenic (Figure 1).

Figure 1: showing three separate trunks and their branches

The gastrophrenic trunk arose from left anterolateral wall of the abdominal aorta, 2 cm distal to the aortic hiatus. It travelled forward for about 5 mm and divided into left gastric artery (LGA) and left inferior phrenic artery (LIPA). Approximately 5 mm distal to the gastrophrenic trunk, there was origin of hepatopsonic trunk from left anterolateral wall of the aorta. It ran forward for about 2 cm and divided into splenic artery (SA) and common hepatic artery (CHA). An interesting finding was that the CHA after giving the gastroduodenal artery became continuous as the left hepatic artery to supply the left lobe of liver. Still 6 mm distal to the hepatopsonic trunk, another trunk, hepatopsonic trunk arose from anterior aspect of the aorta. It ran forward for about 1 cm and gave off replaced right hepatic artery (RRHA) and right inferior phrenic artery (RIPA). The RRHA ran upwards and to the right passing behind the portal vein and common bile duct to supply the right lobe of liver.

3. Review of literature and Discussion

The CT usually arises from the abdominal aorta and trifurcates into its three branches: left gastric, splenic and common hepatic arteries. If two of its branches have a separate origin, there is no coeliac trunk left. Van Damme states that the CT does not trifurcate into its three main branches as is usually depicted, but it bifurcates into the splenic and common hepatic arteries. The third branch, the left gastric artery is a mobile vessel whose origin may slide between the aortas, all over the CT up to a trifurcation. 1

The high incidence of anatomical variations of the CT and its branching pattern was widely described in the literature as observed to vary from classical trifurcation 16-19 to abnormal bifurcations 10, 12, 15, 16 and even absence 17, 18, 19 of the trunk. Generally additional branches other than the normal branches are referred to as collaterals 16, 17, 18, 20, 21, 22, 23. Reported collaterals of the CT include the inferior phrenic, aberrant right hepatic, gastroduodenal, middle colic, dorsal pancreatic, left superior suprarenal, left middle suprarenal, duodenal or ileal arteries 16, 17, 18, 19, 20, 21, 22, 23. Presence of additional arteries may provide collateral circulation which may be important during liver transplant, laparoscopic surgeries, and radiological abdominal interventions in day to day clinical practice 29.

Several authors have studied the branching pattern of the CT 16, 17, 18, 19, 20, 21, 22, 23. They showed that the organization of the CT and its branches presents several variations which are summarised in table 1 and the study of this variability is of clinical significance. It was observed that only 79.8% of the CT exhibited the classical trifurcation. The bifurcation of the CT accounted for 6.6%, absence of the CT in 0.8% and presence of collateral in 12.6%.

<table>
<thead>
<tr>
<th>Author</th>
<th>Population studied</th>
<th>Sample size</th>
<th>Trifurcation %</th>
<th>Bifurcation %</th>
<th>Collaterals %</th>
<th>No CT</th>
<th>HSM/ SM trunk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tiwari</td>
<td>Indian</td>
<td>50</td>
<td>84</td>
<td>2</td>
<td>54</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Chitra</td>
<td>Turkish</td>
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<td>89</td>
<td>8</td>
<td>1</td>
<td>2</td>
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<tr>
<td>Mbaru</td>
<td>Kenyan</td>
<td>123</td>
<td>61.8</td>
<td>17.9</td>
<td>20.3</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Petrella</td>
<td>Brazilian</td>
<td>89</td>
<td>82</td>
<td>5.6</td>
<td>10.1</td>
<td>2.3</td>
<td>-</td>
</tr>
<tr>
<td>Prakash</td>
<td>Indian</td>
<td>50</td>
<td>86</td>
<td>5</td>
<td>4</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Jacob</td>
<td>Indian</td>
<td>40</td>
<td>97.5</td>
<td>-</td>
<td>2.5</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Silveria</td>
<td>Brazilian</td>
<td>21</td>
<td>85.7</td>
<td>9.5</td>
<td>4.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Krishna</td>
<td>Indian</td>
<td>50</td>
<td>92</td>
<td>-</td>
<td>8</td>
<td>-</td>
<td>-</td>
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<tr>
<td>Total</td>
<td>573</td>
<td>79.8</td>
<td>6.6</td>
<td>12.6</td>
<td>0.8</td>
<td>0.2</td>
<td>-</td>
</tr>
</tbody>
</table>

(HSM- hepatopsonic, SM - splenomesenteric)

Differences arising during several developmental stages in the embryonic process lead to a range of variations in these vascular structures. Each dorsal aorta, even before the stage of its fusion, gives ventral splanchnic branches which supply the gut and its derivatives. Initially, these ventral branches are paired. With the fusion of the dorsal aorta, the ventral branches fuse and form a series of unlpaired segmental vessels in the form of 4 roots which run in the dorsal mesentery of the primitive gut. These roots divide into ascending and descending branches to form longitudinal anastomotic channels. The proximal parts of two central roots disappear and distal portions join with the 1st root to form classical 3 branches of the CT and 4th root forms the superior mesenteric artery. Retention or disappearance of parts of this primitive arterial plexus could give rise to numerous anatomical variations in the CT 26, 14.

Figure 2: Diagram showing normal (a-c) development of the coeliac trunk (Source – Kalthur et al 29).

Anatomical variations of the coeliac arterial system were defined according to Michels’ internationally recognized classification 39.

<table>
<thead>
<tr>
<th>Types</th>
<th>Coeliac trunk variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hepato-spleno-gastric trunk (Normal branching)</td>
</tr>
<tr>
<td>2</td>
<td>Hepatosplenic trunk (LGA arises separately)</td>
</tr>
<tr>
<td>3</td>
<td>Hepatosplenesenteric trunk (LGA arises separately)</td>
</tr>
<tr>
<td>4</td>
<td>Hepatogastric trunk (SA from aorta or SMA)</td>
</tr>
<tr>
<td>5</td>
<td>Gastroplenic trunk (CHA from aorta or SMA)</td>
</tr>
<tr>
<td>6</td>
<td>Coeliaco-mesenteric trunk – (SA, LGA, CHA and SMA arise from a common trunk)</td>
</tr>
<tr>
<td>7</td>
<td>Coeliac-colic trunk (Middle colic arises from the CT)</td>
</tr>
</tbody>
</table>

(LGA - left gastric artery, SA - splenic artery, CHA - common hepatic artery, SMA - superior mesenteric artery)
Uğurlu\textsuperscript{14} quoted Uflacker’s classification which is a modification of Michels’ classification. (Table 3)

The hepatosplenic trunk (Type II) and separate LGA from the aorta have been reported in the literature\textsuperscript{10,13,16,18,21,22,26,37}. The LGA commonly arises from the CT as one element of its trifurcation. However, some authors have reported it as arising independently from the aorta\textsuperscript{11,15,16}. Skandalakis has stated that, in approximately 90% of individuals the LGA is a branch of the CT, while in 4% it arises from the gastrosplenic trunk; in 3% it has a direct aortic origin and in 2% it is a branch of hepato-gastric trunk. However it may arise from the CHA, SA or SMA\textsuperscript{32}. In the present case, we found the common trunk of LGA and LIPA - gastro-splenic trunk, arising from the aorta which was similar to Ucerler’s finding\textsuperscript{32}. Nayak\textsuperscript{32} mentioned the same finding reported by Cavdar.

The inferior phrenic arteries (IPAs) are two small arteries which supply the diaphragm. They usually arise from the abdominal aorta just below the aortic hiatus. However, they arise almost frequently from the CT either separately or by a single stem common to both sides\textsuperscript{20}.

McVay Anson\textsuperscript{3} stated the incidence of origin of IPA as follows: Coeliac trunk - 46.8%, Aorta- 45.1%, Renal artery- 4.9%. Left gastric artery -2.6% and Hepatic artery- 0.5%. Pamidi\textsuperscript{21} and Gujaria\textsuperscript{31} quoted the observations of Piano et al stating the origin of IPAs from a) the aorta itself (61.6%), b) ventro-visceral arteries (coeliac-mesenteric system of aorta) including the coeliac trunk (28.2%), and left gastric artery (2.9%), c) the latero-visceral arteries (adreno-renal system) including the middle adrenal artery (2.9%) and renal artery (4.3%).

Mburu studied 123 specimens and observed the origin of IPA from the CT in 4.9%.\textsuperscript{19} The previous study conducted by Tiwari\textsuperscript{36} and Petrella\textsuperscript{38} showed the origin of RIPA alone from the CT in 2% and 5.62%, LIPA alone in 4% and 21.35%, whereas both IPAs in 4% and 7.86% respectively. The origin of LIPA from the LGA is also described in the literature\textsuperscript{11,12,21,22,33,38}. The knowledge of this type of variation shows that surgeons must be cautious to avoid unintentional sectioning of small calibre arteries, as it may occur during the coeliac artery decompression.

The IPAs have received increased attention in the recent years after the discovery of involvement of right or left IPA in the arterial supply and growth of hepatocellular carcinoma (HCC). The IPA is a major source of collateral or parasitized arterial supply to HCC, second to hepatic artery. The great importance of such knowledge lies in the fact that an unsectetable HCC can be treated by transcatheter embolisation of not only its typical blood supply, the right or left hepatic arteries, but also by embolisation of RIPA, if involved\textsuperscript{30}.

The CHA arises from the CT, passes forward and to the right along the upper border of head of pancreas. Here it gives off the gastrophrenic trunk, arising from the aorta which was similar to Ucerler’s finding\textsuperscript{32}. Nayak\textsuperscript{32} mentioned the same finding reported by Cavdar.

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The present case showed a replaced RHA from abdominal aorta in the form of hepatopancreatic trunk which is not consistent with any type described under Michels’ and Hiatt’s classification. Ugurel et al. noted the incidence of replaced RHA in 17% of cases and that especially from the aorta in 1%. The RHA arising from the aorta can be hard to identify and may be divided during the donor operation. Bhardwaj studied 60 cadavers and found the origin of RHA from proper hepatic artery in 65%, from common hepatic artery in 20%, from superior mesenteric artery in 8.3% and from coeliac artery in 6.7%. Out of 180 dissections, Jones and Hardy noted the origin of replaced RHA from SMA in 18%, from gastroduodenal artery in 6% and from right gastric artery or SMA in 1.6%. John Stauffer et al retrospectively reviewed 191 patients who underwent pancreaticoduodenectomy with the help of preoperative imaging and identified replaced RHA from SMA in 12%.

The hepatic artery variations can usually be explained by embryonic development. The liver is supplied during the foetal life by 3 arteries – right hepatic artery from the superior mesenteric artery, left hepatic artery from the left gastric artery and common hepatic artery from the coeliac trunk. With further development, the blood supply assumes the adult pattern, with atrophy of both right and left hepatic arteries and the common hepatic artery gives the right and left hepatic arteries supplying the whole liver. This adult pattern occurs in around 67% of individuals. Anatomical variations correspond to the result of partial or complete persistence of the foetal pattern.

The variations which are reported here have already been reported as individual cases of variations but occurrence of variations of left gastric artery, splenic artery, common hepatic artery, inferior phrenic arteries and right hepatic artery in the same individual have not been reported yet.

It is an accepted fact that variations of the CT do frequently exist and thus its presence may not be undermined. Knowledge of variation found in the present case is very useful in surgical, oncologic or interventional procedures and should be kept in mind to avoid complications. In our opinion, arterial variations should not be ignored during abdominal operative procedures. Complications in abdominal surgeries could be avoided with the accurate knowledge of the anatomical variations of the CT. Preoperative knowledge of the variations of the CT and its branches is essential for surgeons, particularly in the present era of minimal access surgeries.

References

Table 5: modification of Michels’ classification

<table>
<thead>
<tr>
<th>Types</th>
<th>Hepatic artery variation</th>
<th>Hiatt’s classification %</th>
<th>Abdullah’s classification %</th>
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<tbody>
<tr>
<td>I</td>
<td>Normal</td>
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<td>68.1</td>
</tr>
<tr>
<td>II</td>
<td>Replaced or accessory LHA</td>
<td>9.7</td>
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</tr>
<tr>
<td>III</td>
<td>Replaced or accessory RHA</td>
<td>10.6</td>
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<tr>
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<td>Replaced or accessory RHA + Replaced or accessory LHA</td>
<td>2.3</td>
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<tr>
<td>V</td>
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</tr>
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<td>VI</td>
<td>CHA from aorta</td>
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