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Behavioral Anatomy of the Celiac Trunk Based on Human Embryology

Mohammed H. Karrar Alsharif[1*], Khalid M. Taha[2], Abubaker Y. Elamin[3] and Khalid H. Al-Dosari[4]

[1]Department of Anatomy, Prince Sattam Bin Abdulaziz University, Al-Kharj, KSA.
[2]Department of Anatomy, Faculty of Medicine, University of Science and Technology, Khartoum, Sudan.
[3]Department of Emergency Medical Specialty, Al-Ghad International Colleges for Applied Medical Sciences, Al Madinah Al Munawarah, KSA.
[4]Prince Sattam Bin Abdulaziz University, Al-Kharj, KSA.

Authors' contributions

This work was distributed among all authors equally. Author MHKA was assigned to do the literature search. Author KMT managed the scientific writing and corrected the grammatical mistakes. Author AYE was assigned to do the citation and referencing part. Author KHAD carried out the results, discussion and conclusion part. All authors read and approved the final manuscript.

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ABSTRACT

Anatomical knowledge of the coeliac trunk and its branches is indispensable for surgeons in order to avoid post-surgery complications and malpractice and that's what inspired us to review this important topic.
The coeliac trunk is the first ventral branch of arising from the abdominal aorta below the aortic opening of diaphragm.
It is responsible for the blood supply of the not only the foregut but also for accessory organs of gastrointestinal tract (GIT) which include liver, pancreas and biliary apparatus [1]. Anatomic variations are often responsible for a variety of clinical conditions and it's often occurring in the coeliac trunk branches.

**Corresponding author: E-mail: dr.anatomy83@yahoo.com;*

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1. INTRODUCTION

Blood supply of the gastrointestinal tract should be studied through its developmental basis as it is the milestone of understanding it.

The coeliac trunk is the first branch arising from the abdominal aorta anteriorly just below the aortic opening at the level of T12/L1 vertebral bodies. It measures from 1.5-2 cm in length. It has almost horizontal course, passing forward and slightly to the right above the pancreas and splenic vein. It gives rise the left gastric, common hepatic and splenic arteries [2].

During the third week, the embryo undergoes two processes of folding "cephalocaudal and lateral folding". This makes the ventral part of the chorionic vesicle (yolk sac) to become incorporated into the embryo forming the primordial gut. While the splanchnic mesenchyme surrounding the primordial gut gives rise to the muscular and connective tissue components of the digestive tract, the whole GIT epithelial lining is derived from the endoderm of the primordial gut except for the most cranial and caudal parts, the stomodeum and proctodeum which are derived from the ectodermal layer [1].

The foregut forms the pharynx, esophagus, stomach, upper part of the duodenum, parenchyma of the liver, pancreas, and the biliary system. The foregut also participates in the formation of the lower respiratory tract [1].

The midgut elongates to form the intestinal loop. This loop develops into the duodenum distal to the bile duct's opening, the jejunum, the ileum and the proximal two-thirds of the transverse colon. At its apex the primary loop remains temporarily in open connection with the yolk sac through the vitelline duct. During the sixth week, the loop grows so rapidly that it protrudes into the umbilical cord (physiological herniation) and retracts into the abdominal cavity during the 10th week. While these processes are occurring, the midgut loop rotates 270° counterclockwise [1].

The hindgut develops into the distal one third to one half of the transverse colon, the descending and sigmoid colons, the rectum, and the upper part of the anal canal. The lower part of the anal canal is of ectodermal origin "the proctodeum". The cloaca, the lower part of the hindgut, is divided by the urorectal septum into the urogenital sinus that gives rise to the urinary bladder and urethra, and anorectal canal which gives rectum and upper part of the anal canal. The superior part of the anal canal is separated from the inferior by the anal membrane. This membrane perforates by the end of the 8th week [3].

1.1 Normal Development of Aorta

The aortic sac which is continuous caudally with truncus arteriosus, gives six pharyngeal aortic arch arteries on both sides. These arch arteries join together dorsally to form two dorsal aortae that join to form one common aorta caudal to the 4th thoracic somite. This aorta forms the descending aorta passing in the thoracic and abdominal cavity [4].

1.2 Coeliac Trunk (Coeliac Axis)

The coeliac trunk is the first branch arises from the abdominal aorta anteriorly just below the aortic opening of diaphragm at the level of T12/L1 vertebral bodies. It measures from 1.5-2 cm in length. It has almost horizontal course, passing forward and slightly to the right above the pancreas and splenic vein. It gives rise into the left gastric, common hepatic and splenic arteries. The coeliac trunk might also give off both inferior phrenic arteries or one of them [3].

The superior mesenteric artery arises from the abdominal aorta below the coeliac trunk. It might also arises with the coeliac trunk as a common origin. Some of the superior mesenteric arteries branches might arise from the coeliac trunk. The coeliac ganglia lie bilaterally; and the coeliac plexus surrounds the trunk reaching out the targets through the branches of the trunk. On the right of the coeliac trunk lie right crus of the diaphragm and the caudate lobe of the liver. The right crus may compress the coeliac trunk at its origin, giving it the appearance of a stricture. To the left lie left crus as well as the cardiac end of the stomach. Inferior to the coeliac trunk lie the head of the pancreas and the splenic vein. The Coeliac trunk also called the artery of the foregut because it supplies the derivatives of the foregut [3].

The celiac trunk arises at the level of T12 vertebra "at its lower margin", but it might also originate the level of L1. The site of origin is usually 1 cm superior to the origin of the superior

mesenteric artery [3]. The coeliac trunk usually trifurcate into its three main branches, but it may only divide into the splenic and the common hepatic arteries. The left gastric artery has various sites of origin, the origin might slide between the aorta leaving a hepatosplenic trunk all over the celiac trunk up to a real trifurcation. Sometimes the whole trunk might originate as a common trunk with the superior mesenteric artery (celiacomesenteric trunk). The coeliac trunk may have one of its branches coming from a separate origin either from the superior mesenteric artery or the aorta. In case of two of its branches come from a separate origin, there is no celiac trunk. The hepatic artery pulls the coeliac trunk to the right. But if the hepatic artery arised from the celiac trunk, the remaining trunk (gastrosplenic) is pulled to the left and looks to continue into the splenic artery. The splenic artery usually has no variants of origin usually. One of the most common collateral variations of the celiac trunk is a single or double inferior phrenic artery [5].

2. BRANCHES

There are three main divisions of the celiac artery, and each in turn has its own named branches (Fig. 1):

1. **Left gastric artery** arises from the celiac artery and runs along the superior portion of the lesser curvature of the stomach. Branches also supply the lower esophagus. The left gastric artery anastomoses with the right gastric artery, which runs right to left.
2. **Common hepatic artery** is a short blood vessel that supplies oxygenated blood to the liver, pylorus (a part of the stomach), duodenum (a part of the small intestine) and pancreas. It arises from the celiac artery and has the following branches:

   a- Hepatic artery proper (also proper hepatic artery), arises from the common hepatic artery and runs alongside the portal vein and the common bile duct to form the portal triad. The common hepatic artery gives off a small supraduodenal artery to the duodenal bulb. Then the right gastric artery comes off and runs to the left along the lesser curvature of the stomach to meet the left gastric artery, which is a branch of the celiac trunk. It subsequently bifurcates into the right and left hepatic arteries. Of note, the right and left hepatic arteries may demonstrate variant anatomy. A replaced right hepatic artery may arise from the superior mesenteric artery (SMA) and a replaced left hepatic artery may arise from the left gastric artery. The cystic artery generally comes off of the right hepatic artery [7].

   b- Gastroduodenal artery is a small branch that provides blood supply directly to the pylorus of the stomach and proximal part of the duodenum, and also supplies the head of the pancreas indirectly (via the anterior and posterior superior pancreaticoduodenal arteries). The artery commonly arises from the common hepatic artery but it might also come from a different sites of origin.

   It first gives rise to the supraduodenal artery and posterior superior pancreaticoduodenal artery. It terminates by bifurcating into the anterior superior pancreaticoduodenal artery (the superior pancreaticoduodenal artery) and the right gastroepiploic artery. These branches form functional anastomoses with the superior mesenteric artery branches (anterior and posterior inferior pancreaticoduodenal arteries). Typically, the posterior and anterior superior pancreaticoduodenal arteries arise independently in that order, but the exact branching of the vessels from the gastroduoenal artery is variable and can rarely come of a common trunk [8].

   c- Right gastric artery: is a branch that supplies the pyloric portion on lesser curvature of stomach and also shares in supplying the lower part of esophagus.

3. **Splenic** artery (in the past called the lienal artery) is the blood vessel that supplies oxygenated blood to the spleen. It branches from the celiac artery, and follows a course superior to the pancreas. it has the following branches:

   i. **Branches to the pancreas:** They are multiple branches serving the pancreas. The largest is the arteria pancreatica magna.
   ii. **Short gastric arteries** to upper part of greater curvature of the stomach.
   iii. **Left gastroepiploic artery** to middle of greater curvature of the stomach.
   iv. **Posterior gastric** artery to posterior of stomach (if is it present).

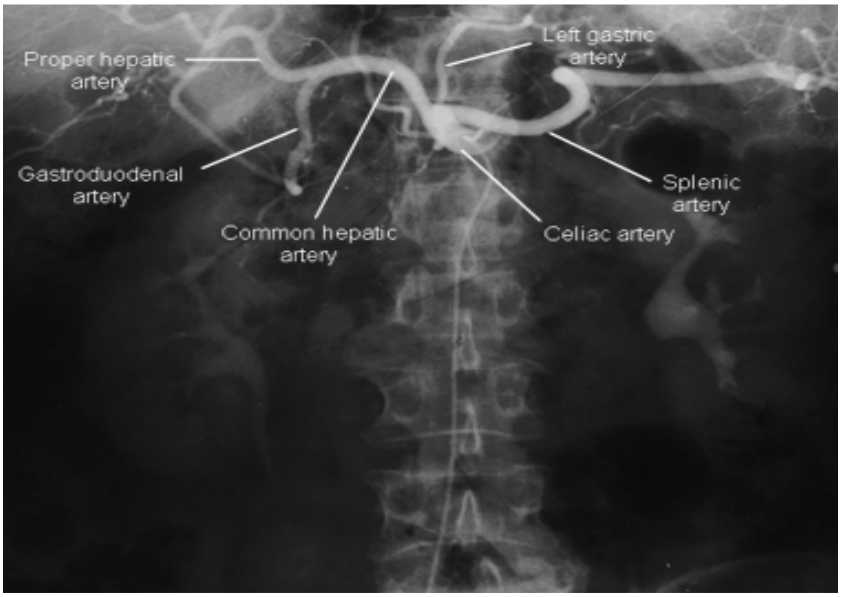

Fig. 1. Arteriogram of the celiac trunk and branches [6]

2.1 Anatomic Variation of Celiac Trunk Branches

A case of celiacomesenteric trunk was in Çavdar et al. [5]; is reported, a variation found in only 1 percent to 2.7 percent of the population [5].

Of the three anterior visceral branches of the aorta, the celiac trunk is the most prone to variations. As reviewed by Lippert and Pabst [9], some of these variations and their occurrence percentages in the population are as follows:

- Origin of inferior phrenic artery from celiac trunk: 50%.
- The left gastric artery arises early from celiac, followed by hepatosplenic bifurcation: 49%.
- "Typical" trifurcation of celiac trunk into Splenic, Common hepatic and Left gastric: 25%
- Hepatosplenic trunk: 5% (Left gastric has separate origin from aorta.)
- Gastrosplenic trunk: 3% (Common hepatic independently arises separately from aorta.)
- Gastrohepatic trunk: 1% (Splenic artery arises separately from aorta.)
- Gastrohepatosplenomesenteric trunk: 2% (Celiac and superior mesenteric as a common trunk)
- Hepatomesenteric trunk: 3% (Splenic and left gastric as a common trunk.)

2.1.1 Celiac trunk absence

Celiac trunk absence is uncommon medical case. The percentage of absence of celiac trunk based on 19 studies with 10,750 cases is 0.19% [10]. According to a case report of celiac trunk absence in gross dissection of male cadaver the three branches of celiac trunk arise directly from abdominal aorta [11]. The left gastric artery arises from anterior wall of abdominal aorta directly, about 4 mm left to inferior phrenic artery (LIP) origin. About 10 mm from left gastric artery origin, from the left side of anterolateral wall of abdominal aorta the splenic artery arises. Directly in the lower right side of splenic artery the common hepatic artery is located.

2.2 The Posterior Gastric Artery (PGA)

It is important to define this artery in a lot of surgical procedures such as subtotal gastrectomy, splenectomy and pancreatic transplantation. According to study done by Loukas depending on 120 adult human cadavers, the posterior gastric artery (PGA) can be defined as an artery which supplies the posterior aspect of stomach close to the area of cardia and fundus [12].

The posterior gastric artery was identified in 81.6% of cases. The most common origin was from the left gastric artery (Type I) in 41.8% of cases. In decreasing order, in 25.5% origin was

from the splenic artery (Type II); in 22.4% from both of the left gastric and splenic arteries as double posterior gastric arteries (Type III); and occurring in 10.2% of the cases from the celiac trunk (Type IV). The importance of accurate PGA delineation is crucial for pancreatic transplantation and gastric tumor removal. In addition, knowledge of variant anatomy in this vessel's origin has proven usefulness in transcatheter arterial embolization for the treatment of chronic bleeding from gastric ulcers. Furthermore, ligation of the posterior gastric artery during partial gastrectomy, pancreaticoduodenectomy and parietal cell vagotomy might result in gastric wall necrosis and gastric stump leak [12].

2.3 Clinical Correlation of Celiac Trunk

2.3.1 Celiac artery compression syndrome

Celiac Artery Compression Syndrome (Also named median arcuate ligament syndrome " MALS"): A lot of terms were used to describe this case for example celiac trunk syndrome by Harjola & Lahtiharju [13] and celiac compression syndrome by Marable et al. [14] Also named median arcuate ligament syndrome " MALS" . The median arcuate ligament is present normally as a fibrous arch passing over the abdominal aorta connecting the right and left crura of diaphragm. The median arcuate ligament passes in front of the aorta at the level of first lumber vertebra, just above the origin of celiac artery [2]. In case of MALS, the ligament is inserted lower than its normal position compressing the proximal part of the celiac artery [15]. The usual symptom of MALS patients is abdominal pain caused by decrease of celiac artery blood flow. A case report also shows other important signs like nausea, nonbilious emesis, weight loss and bloating [16]. Computed tomographic angiography plays an important role in diagnosing of celiac artery compression syndrome [15].

2.3.2 Celiac trunk aneurysm

It means a localized, blood-filled balloon-like bulge in the wall of celiac artery. The celiac artery aneurysms are one of the rarest forms of splanchnic artery aneurysm. Less than 180 cases have been reported in the medical literature [17]. Usually celiac trunk aneurysm is asymptomatic and can be diagnosed via diagnostic imaging. The most serious complication is ruptured celiac trunk aneurysms. Such rupture can be fatal.

2.3.3 Dissection of the celiac trunk

Isolated spontaneous celiac trunk dissection (ISCTD) without associated aortic disease is rare condition and only case reports have been described in the literature [18-20]. Arterial dissection can be defined as a cleavage of the arterial wall between two elastic layers and local hematoma formation [21]. The spontaneous dissection of visceral arteries is very rare condition in superior mesenteric artery but it can affect the celiac trunk and the splenic artery [22-25]. The exact pathogenesis of isolated spontaneous celiac trunk dissection remains unclear, but risk factors for visceral artery dissection include atherosclerotic disease, segmental arterial mediolysis, hypertension, fibromuscular dysplasia, cystic medial necrosis, and connective tissue disorders [18,26,27].

2.3.4 Arteriovenous malformations (AVMs)

It can be defined as defects in the vascular system, consisting of tangles of abnormal blood vessels in which the feeding arteries are directly connected to a venous drainage network without interposition of a capillary bed [28] It occurs due to an embryonic failure in the vascular development of the affected region. From the celiac branches, the most commonly affected artery is the common hepatic artery, which forms one of arterioportal shunts. This type of communication between the hepatic artery and the portal vein, is the most serious complication as it may cause portal hypertension.

3. CONCLUSION

A good understanding of celiac trunk architecture and its anatomical variants plays an important role in the prevention of surgical and angiographic malpractice that can occasionally become catastrophic. Accordingly, any anatomical variation should be reported, mainly in patients undergoing surgical and/or angiographic procedures.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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