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Review article

COELIAC TRUNK VARIATIONS:REVIEW WITH PROPOSED NEW CLASSIFICATION

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ABSTRACT

Coeliac Trunk (CT), the first ventral branch of the abdominal aorta is the major source of blood supply to the supracolic abdominal compartment. Usually, it branches into the splenic, common hepatic and left gastric arteries to supply this region. Anatomical variations of celiac trunk and its branching pattern frequently found during cadaveric dissection and diagnostic radiological imaging have been reported by numerous authors. Although the variations in coeliac trunk are usually asymptomatic, they may become important in patients undergoing diagnostic angiography for gastrointestinal bleeding or prior to an operative procedure. The knowledge of this results in more accurate treatment. In the past many years, investigators have classified the CT based on its branching pattern. However, these classifications have not been able to encompass all the types of variations that have been reported till date. Therefore, in this article we have tried to include most of the types of variations reported till date and put forward a new classification of CT that incorporates most of the variations reported so far. Besides this an attempt has been made to explain the embryological basis of these variations.

KEYWORDS: Coeliac Trunk, Variations, New classification, Embryological basis, Branching pattern.

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INTRODUCTION

"Variability is the law of life"
-Sir William Osler

The coeliac artery, also known as the celiac trunk (CT) or coeliac axis is the first ventral branch of the abdominal aorta. It is a short wide branch about 1.25cm long , that arises from the aorta at the level of T12–L1 vertebrae immediately below the aortic hiatus of the diaphragm. The celiac axis and its branches supply the derivatives of foregut i.e. stomach, spleen, pancreas, liver and part of the duodenum. [1].

The most common classical type of branching of CT is known as trifurcation (Fig. 1) and was first described by Haller in 1756 as tripus Halleri [2]. It is considered to be the normal branching pattern of the CT and the three main branches are left gastric artery (LGA), common hepatic artery (CHA) and splenic artery (SA).

Of the three branches of CT, the LGA is the smallest. It passes upwards to the left to reach the cardiac end of the stomach and gives branches to the lower end of the oesophagus and stomach. The CHA arises from the right side of the celiac trunk and passes forward and to the right to the upper border of the first part of duodenum. It gives origin to right gastric artery and gastrodudenal artery. Then it runs upwards and to the right to reach the porta hepatis of liver. The artery is known as proper hepatic artery beyond the origin of gastroduodenal artery. SA is the largest branch of CT and is remarkably tortuous. The artery ascends to the left behind the omental bursa along the superior border of pancreas to reach the hilum of spleen. Near the spleen it divides into five or more branches. Besides branches to

spleen it also gives pancreatic branches, short gastric arteries and left gastroepiploic artery.

A plethora of information is available in literature on the variation in the origin and branching pattern of CT. Large number of variations have been observed by the investigators during cadaveric dissection or diagnostic angiography or surgeries. An embryological explanation for these variations has been provided by Tandler [3].

The knowledge of variations in origin and course of branching pattern of celiac trunk is not only of anatomical and embryological interest but also of clinical significance as these variations can be the source of pathological conditions, or in patients undergoing diagnostic angiography for gastrointestinal bleeding or prior to an operative procedure. Recognition of CT variations is becoming mandatory in planning surgical and interventional procedures.

It is important to understand that anatomical diversity and variation is a rule of living organisms and it is the responsibility of textbook writers and teachers to transmit this crucial concept to their students. Failure to do so leads to the belief that textbooks convey immutable facts with only few anomalous exceptions. In this article therefore, an attempt has been made to consolidate the data from the earlier research to give an account of the variations reported so far regarding the anatomy of the coeliac trunk and to put forward some theories for the cause of such variations. The specific aspects explored include extending the classification of celiac trunk based on the branching pattern of CT and developmental basis of the variations. As mentioned earlier it is essential to have full comprehension of CT variations, as knowledge of these variations is indispensable in operative and diagnostic procedures within the abdomen.

Classification of Coeliac Trunk:

Various authors have classified the celiac trunk based on its branching pattern. The anatomical variations of CT were classified for the first time in 1917 by Lipshutz [4] into 4 types based on the mode of origin and distribution of gastric, splenic and hepatic arteries (Table 1). In 1928 Adachi [5] classified anatomical variations of the coeliac trunk into six types (Table 2). He included the origin of superior mesenteric artery along with the CT and its branches. Michels 1951 [6] also classified the coeliac trunk into six different types (Table 3). Five of the six types of CT reported by Adachi and Michel were same, the only exception was that Adachi observed hepatomesentric trunk as one of the variations whereas Michel observed hepotogastic type of CT. In 1997 Uflacker [7] classified the CT into eight types which included all the previously reported classification types of CT and added two more variants i.e. absence of CT and coeliac-colic trunk (Table 4). Absence of CT and origin of its branches directly from the abdominal aorta termed “agenesis of CT” has been also reported by other authors besides Uflacker (1997), [8,9].

Type	CT Branching pattern
I	Normal trifurcation
II	Hepatosplenic trunk
III	Hepatogastric trunk
IV	Gastrosplenic trunk

Table 1: Lipshutz’s Classification of CT [4].

Type	CT Branching pattern
1	Hepatogastrosplenic
2	Hepatosplenic
3	Hepatosplenomesentric
4	Coeliacomesenteric
5	Hepatomesentric
6	Gastrosplenic

Table 2: Adachi’s classification of celiac trunk variations [5].

Type	CT Branching pattern
1	Normal branching –Trifurcation
2	Hepatosplenic trunk
3	Hepatosplenomesentric trunk
4	Hepatogastric trunk
5	Splenogastric trunk
6	Coeliacomesentric trunk;

Table 3: Michels classification of variations of celiac trunk [6].

Type	CT Branching pattern
I	Classic coeliac trunk
II	Hepatosplenic trunk
III	Hepatogastric trunk
IV	Hepatosplenicmesenteric trunk
V	Gastrosplenic trunk
VI	Coeliac-mesenteric trunk
VII	Coeliac-colic trunk
VIII	No coeliac trunk

Table 4: Uflacker’s classification [7].

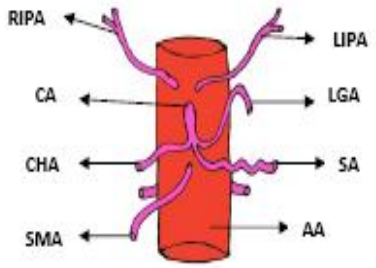


FIGURE - 1: Usual branching pattern of Coeliac Trunk.

LGA – Left Gastric Artery, **SA** – Splenic Artery, **CHA** – Common Hepatic Artery, **SMA** – Superior Mesenteric Artery, **RIPA** – Right Inferior Phrenic Artery, **LIPA** – Left Inferior Phrenic Artery, **CA** – Celiac Artery, **AA** – Abdominal Aorta.

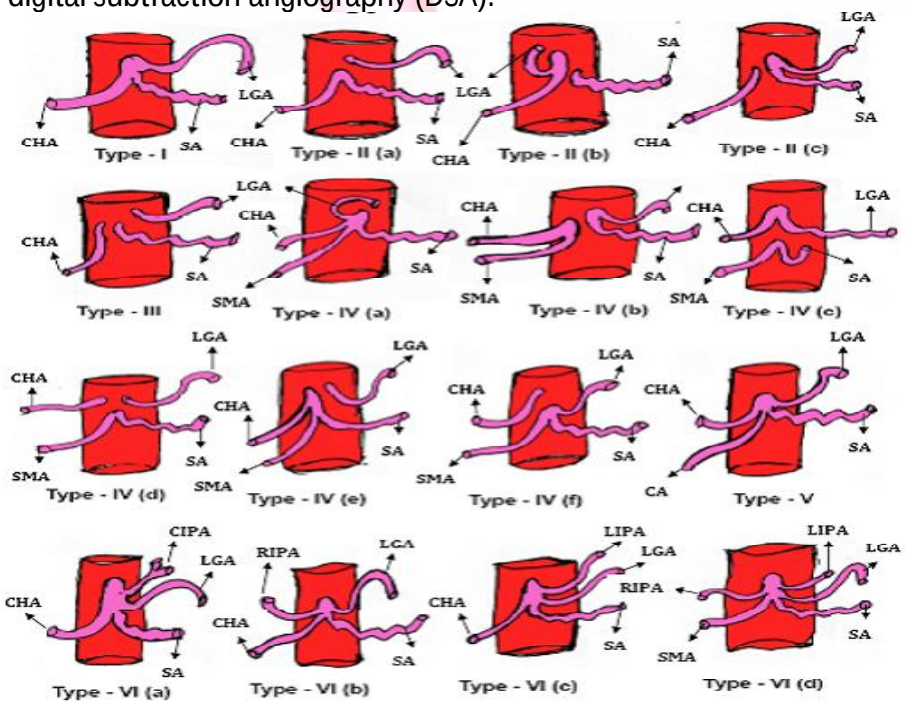
However, all the variations of branching pattern of CT reported so far have not been described in classification given by Lipshutz, Adachi, Michels and Uflacker. The branching pattern of the coeliac trunk has been reported to vary from classical trifurcation to abnormal trifurcation, bifurcation, quadrifurcation, pentafurcation and even hexafurcation of the trunk. The additional branches of the trunk reported in literature include the inferior phrenic artery, superior mesenteric artery, gastroduodenal artery, middle colic artery, dorsal pancreatic artery [4,24,29,30]. According to Song et al [10] fifteen types of celiac trunk variations including normal celiac trunk are theoretically possible and they identified thirteen types in 5002 patients using spiral computed tomography (CT) and digital subtraction angiography (DSA).

S.No	Trunk classification number	CT Branching pattern
1	Type I	Normal trifurcation
2	Type II(a)	Hepatosplenic trunk
3	Type II(b)	Hepatogastric Trunk
4	Type II(c)	Gastrosplenic Trunk
5	Type III	No coeliac Trunk
6	Type IV (a)	Celiacomesenteric Trunk
7	Type IV (b)	Hepatomesentric Trunk
8	Type IV (c)	Gastro mesenteric Trunk
9	Type IV (d)	Splenomesenteric Trunk
10	Type IV (e)	Hepatosplenomesenteric Trunk
11	Type IV (f)	Gatrosplenomesenteric Trunk
12	Type V	Coeliaccolic Trunk
13	Type IV (a)	Coeliophrenic Trunk (CT+ CIPA)
14	Type IV (b)	Coeliophrenic Trunk (CT+ RIPA)
15	Type IV (c)	Coeliophrenic Trunk (CT+ LIPA)
16	Type IV (d)	Coeliophrenic Trunk (CT+ RIPA + LIPA)

Table 5: New Coeliac Trunk classification (proposed)

CT – Celiac Trunk, **CIPA** – Common Inferior Phrenic Artery, **RIPA** – Right Inferior Phrenic Artery, **LIPA** – Left Inferior Phrenic Artery.

After going through the vast literature available on variations in CT we propose a new classification of CT describing six main types with subtypes in each category (Table 5 and Fig 2). Table 6 shows incidence of the variations of CT reported by the different investigators in different populations according to our proposed classification of CT.



LGA – Left Gastric Artery, **SA** – Splenic Artery, **CHA** – Common Hepatic Artery, **SMA** – Superior Mesenteric Artery, **RIPA** – Right Inferior Phrenic Artery, **LIPA** – Left Inferior Phrenic Artery, **CA** – Celiac Artery, **AA** – Abdominal Aorta.

FIGURE – 2: Schematic diagram showing variation in the origin of celiac trunk and its branches.

		Coeliac Trunk classification																		
		Type I	Type II (Incomplete CT)			Type III	Type IV						Type V	Type VI (CT + IPA/s)						
Authors name and year	Population	Normal trifurcation	II a Hepatosplenic trunk	II b Hepatogastric Trunk	IIc Gastrosplenic Trunk	No coeliac Trunk	IVa Celiacomesenteric Trunk	IVb Hepatomesentric Trunk	IVc Gastro mesenteric	IVd Splenomesenteric	IVe Hepatosplenomesenteric Trunk	IVf Gastroslenomesenteric Trunk)	Coeliacco lic Trunk)	VIa Coeliophrenic Trunk (CT+ CIPA)*	VIb Coeliophrenic Trunk (CT+ RIPA)**	VIc Coeliophrenic Trunk (CT+ LIPA)***	VId Coeliophrenic Trunk (CT+ RIPA + LIPA)****	Others	No. of cases	Type of study
Lipschutz 1917[4]	Philadelphia	49.4	25.3	3.6	14.5														83	Cadaveric
Adachi 1928[5]	Japan	86	8		3		15	0.5			1								252	Cadaveric
Wadhwa and Soni2011[11]	India	93.3	6.7																30	Cadaveric
Prakash et al 2012 [12]	India	86	8	2															50	Cadaveric
Chitra 2010 [13]	India	40	2		4			2					2					50	50	Cadaveric
Pushpalatha 2006 [9]	India	70			4	4										14	4.0	4	50	cadaveric
Sawant et al 2013 [13]	India	86	2													4		8	50	cadaveric
Mburu et al2010 [15]	Kenya	61.7	13.1		4.9													20.3	123	Cadaveric
Ugurel 2010 [8]	Turkey	89	3	1	4	1				1	1								100	CT angiography
Chen et al2009 [16]	Japan	89.8	4.3	0.2	1.8		0.7	1.5		0.2	0.7							1	974	Cadaveric
Song et al 2010 [10]	Korean	89.1	4.4	0.2	0.2		1.1	2.9	0	3	0.7	0.2						1.3	5002	CT spiral and DSA
Shoumura 1991[17]		90.6	2.6		1.8	2			0.4									1.1	450	
Imakeshi.K1949 [18]		90.7	3.7		0.9		0.9	1.9			0.9							0.9	107	
Kozhevnikava1997 [19]		87	7.7															5.5	155	
Malnar et al 2010 [20]	Croatia	92					4				4								90	
Tiwari & Jeyanthi 2012 [21]	India														2	4	2	2	50	Cadaveric
Wadhwa & Soni 2012 [22]	India													13	23	20			30	Cadaveric

Table 6: Compilation of the data available on the variations in branching pattern of celiac trunk according to the new classification.

S. No.	Author Name and Year	Branching pattern of the coeliac trunk	Types of branching	No. of cases
1	Yalcin et al 2004 [23]	CHA+SA+Middle Supra Renal Artery + LGA and LIPA have common trunk	others	1
2	Nayak et al. 2008 [24]	LIPA+ CHA + SA + LGA & GDA	Others	1
3	Astik & Dave 2011[25]	Left Supra Renal Atery + Left Middle Supra Renal Artery+ SA + CHA + LGA + GDA & RIPA	Others	1
4	Paraskevas &Raikos 2011[26]	LGA + SA + CHA + LIPA + Left SRA & Ass. Jejunal Artery	Others	1
5	Anita et al.2009[27]	LGA+ CHA + SA + Ass. H. A & Retroportal Artery	Others	1
6	Suganthy et al.200[28]	LGA+ SA + CHA + Gastroepiploic Artery	Others	1
7	Sathidevi & Rahul 2013 [29]	LGA+ SA + CHA + GDA	Others	1
8	Kalthur et al2011[30]	LGA+ SA + CHA + DPA	others	1

Table7: Consolidation of the data available on branching pattern of rare celiac trunk presented as case reports.

LGA – Left Gastric Artery,
SA – Splenic Artery,
CHA – Common hepatic Artery,
SMA– Superior Mesenteric Artery,
RIPA – Right Inferior Phrenic Artery,
LIPA – Left Inferior Phrenic Artery,
GDA - Gastro-Duodenal Artery,
LSRA - Left supra Renal Artery,
DPA-Dorsal Pancreatic Artery.

Some of the cases reported could not be put into any category and have been included under the heading 'Others'. Some interesting rare variations of CT reported as case reports are consolidated in Table 7.

Embryology

The anatomical variations in celiac trunk related to its diameter, length or location are thought to have an embryological basis [3]. Each dorsal aorta gives paired ventral splanchnic branches which supply yolk sac, the primitive gut and its derivatives. With the fusion of the dorsal aortae during 4th week of intrauterine life(IUL), the ventral branches fuse and form a series of several unpaired segmental vessels, which run in the dorsal mesentery of gut and are connected by ventral longitudinal anastomosing channel. With the formation of longitudinal anastomotic channel, numerous ventral splanchnic branches are withdrawn and ultimately only three trunks persist as coeliac artery for foregut, superior mesenteric artery to midgut, and inferior mesenteric artery to hindgut (3).

According to Tandler (1904)[3] the 11th and 12th ventral segmental roots disappear, the 10th and 13th roots remain connected via the ventral anastomoses. The common hepatic, left gastric and splenic arteries usually originate from the longitudinal anastomosis. These branches are usually separated from the 13th root (the future superior mesenteric artery). If this separation takes place at the higher level, one of the

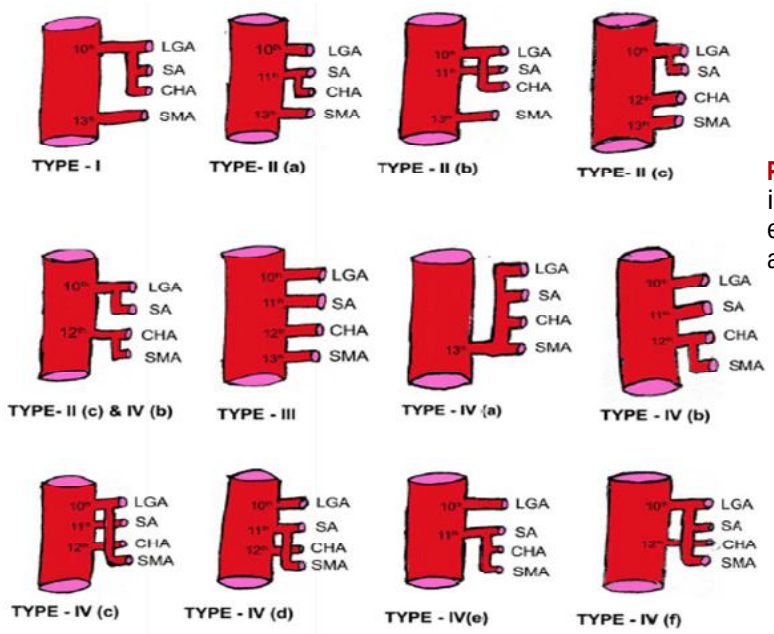


FIGURE - 3: Schematic diagram showing the developmental pattern of Coeliac trunk and superior mesenteric artery.

LGA – Left Gastric Artery,
SA – Splenic Artery,
CHA – Common hepatic Artery,
SMA – Superior Mesenteric Artery.

branches of celiac trunk is displaced to the superior mesenteric artery. If the 10th or 13th root disappears, a coeliaco-mesenteric trunk is formed. The embryological basis for the occurrence of other variations of CT is shown diagrammatically in Fig 3.

CONCLUSION

In the present article the data derived from earlier research has been consolidated to give an account of the majority of the variations reported in the anatomy of the coeliac trunk. However, all the variations of branching pattern of CT reported so far have not been included in the previous classifications given by Lipshutz, Adachi, Michels and Uflacker . Therefore , after going through the vast literature available on variations in CT we propose a new classification of CT describing six main types with subtypes in each category which include most of the variations. The embryological basis for the cause of such variations has also been provided.

In recent times , trends in surgical procedures are to move towards minimal invasive surgery , therefore we would like to emphasize the importance of thorough knowledge of normal anatomy of CT and its variations in clinical medicine. It will not only help in avoiding iatrogenic injury but will also play a significant role in the surgical intervention in the abdominal region , in angiographies of ventral branches of abdominal aorta and as well as facilitate better and more accurate radiological interpretation.

Conflicts of Interests: None

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