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Original Article

Anatomy Section

Study of Normal Branching Pattern of the Coeliac Trunk and its Variations Using CT Angiography

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ABSTRACT

Introduction: Blood vessel anomalies are always interesting from embryological view and of considerable significance from a clinical or a surgical standpoint. Vascular anomalies are usually asymptomatic; they may cause problems in patients undergoing diagnostic angiography or any operative procedure. The length and course of the coeliac artery are variable and its branches frequently arise separately from the main trunk. Several other branches may additionally arise from the coeliac trunk, for example, inferior phrenic arteries, the dorsal pancreatic artery, and the middle colic artery.

Aim: The present study was undertaken to analyse the vertebral level of origin of coeliac artery, its branching pattern and the associated variations using computed tomographic angiography in 75 subjects.

Results: The results obtained were analysed and classified based on Adachi's and Lipshutz's classification method. The results were also compared with various other studies cited in the literature. The level of origin was found to be at the inter-vertebral disc between T12 and L1 in a majority of the cases (70.6%). It was also found that the coeliac trunk trifurcates in majority of the cases i.e. 90.6%. Trifurcation was of two types, classical and non-classical, the classical trunk being the commonest type. Variations included bifurcation of the trunk (8%) with Left gastric artery arising directly from the aorta, in a few cases (1.3%) Common hepatic artery arose as a separate trunk from the aorta.

Conclusion: A comprehensive knowledge of this arterial anatomy and variations will be very useful when planning abdominal surgeries and image-guided interventions. The success of procedures such as liver transplantation, intestinal anastomosis, intra-arterial chemotherapy, chemo-embolization, and radio-embolization requires a detailed knowledge of the coeliac artery and its anatomical variants, which are extremely common, to avoid iatrogenic injuries and to prevent complications.

Keywords: CHA: Common Hepatic Artery, CT: Computed Tomography, CTA: Computerized Tomographic Angiography, DPA: Dorsal Pancreatico Duodenal Artery, GDA: Gastro Duodenal Artery, IMA: Inferior Mesenteric Artery

INTRODUCTION

The coeliac trunk is a highly significant artery supplying various abdominal organs. The literature available signifies that the anatomy of the coeliac trunk is not uniform for all human beings and a certain amount of population shows significant variations from the typical branching pattern. Data derived from the previous researches [1-6] has been analysed to give a detailed account of the major variations found in coeliac trunk but to put forward some theories for the cause of such variations, it is necessary to achieve full comprehension of the topic. The present study on branching pattern of coeliac trunk is a preliminary step taken to throw light on the embryological reasons behind these clinically significant variations.

AIM

To find out the vertebral level of origin and branching pattern of the coeliac trunk from the abdominal aorta using CT angiograph pictures.

MATERIALS AND METHODS

CT ANGIOGRAPHIC STUDY: Subjects who attended the Radiology Department of Saveetha Medical College and Hospital between June 2013 and August 2013 to undergo abdominal aorta CT for various reasons were included in the study. A total number of 75 subjects were thus recruited for this study.

Vertebral Level	No. of cases (out of 75)
T12	8
T12 – L1	53
L1	14

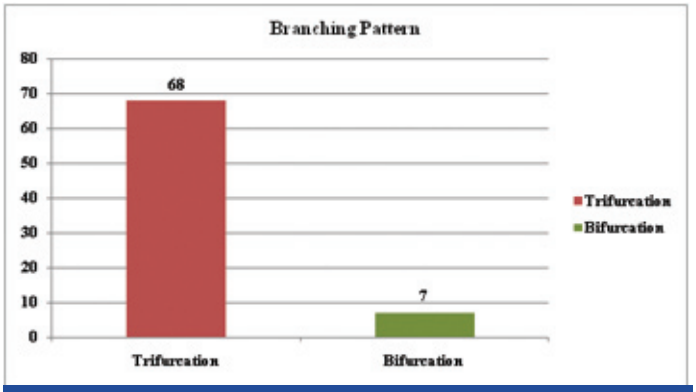
[Table/Fig-1]: Level of Emergence of coeliac trunk from the abdominal aorta, based on number of cases

RESULTS

Vertebral level: In the current study of 75 subjects, the coeliac trunk arose from the aorta at the level of T12 vertebra in 8 cases (10.7%), inter-vertebral disc between T12 and L1 in 53 cases (70.7%) and L1 vertebra in 14 cases (18.6%) [Table/Fig-1].

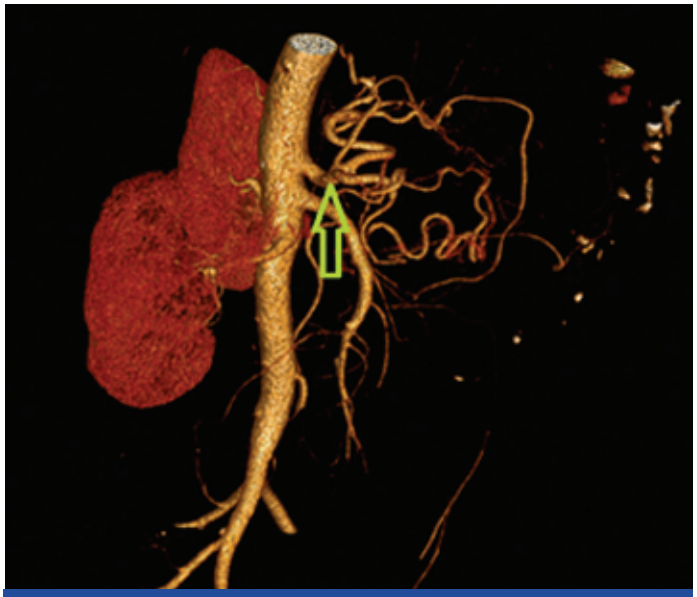
Branching pattern: The coeliac trunk gave rise to distributive visceral branches that were either classical (left gastric, splenic and common hepatic) or collaterals. Out of 75 cases, coeliac trunk was trifurcated in 68 (90.6%) and bifurcated in 7 (9.3%) of the cases [Table/Fig-2].

Two different trifurcation patterns were found; a classical tripod called "tripus Halleri" and a non-classical type. In the classical type, the common hepatic, splenic and left gastric arteries originated from a common point. Out of 75, this pattern was observed in 59 (86.7%) of the cases [Table/Fig-3]. In the Non-classical type, there was a common point of origin for the hepatic and splenic arteries while



[Table/Fig-2]: Branching pattern observed among 75 cases

the left gastric had a different point of origin. This was observed in 9 (13.2%) of the cases [Table/Fig-4]. The observations of the branching pattern of coeliac trunk, which were found in this study were categorized based on Adachi's [1] classification [Table/Fig-5]. The branching pattern of the coeliac trunk was also studied using Lipshutz's [7] classification method and the findings were tabulated [Table/Fig-6].



[Table/Fig-3]: VRT image (lateral view) showing normal trifurcation of coeliac trunk

[Table/Fig-4]: VRT image showing non classic trifurcation. LGA is given off early

Trunk classification	Classification number	No of cases (out of 75)	Percentage
Hepatogastrosplenic	1	68	90.6%
Hepatosplenic	2	6	8.0%
Gastrosplenic	4	1	1.3%
Coeliacomesenteric	6	-	0%
Hepatosplenomesenteric	3	-	0%
Hepatomesenteric	5	-	0%

[Table/Fig-5]: Observations based on Adachi's classification

Type I	68	90.6%
Type II	6	8%
Type III	0	0%
Type IV	1	1.3%

[Table/Fig-6]: Variations of coeliac trunk based on Lipshutz's classification

DISCUSSION

Vertebral Level

In the current study of 75 cases, the coeliac trunk arose from the aorta at the level of T_{12} vertebra in 8 cases (10.7%) inter-vertebral disc between T12 and L1 in 53 cases (70.7%) and L1 vertebra in 14 cases (18.6%). The current study results were similar to the results of Wadhwa A who studied the branching pattern in 30 cadavers [2]. It was reported that in 22 cases (73.3%) the Coeliac trunk arose at the level of inter-vertebral disc between T12 and L1 and in 8 cases (26.6%) at the level of upper part of L1 vertebra. According to HS Surucu et al., [6] the coeliac trunk emerged at T12 level in 79.8%, at L1 level in 14.4% and at T11 level in 3.8% of the cases. The present study findings were also favourable to the study conducted by Hofman and Watson [8], Moncada et al., [9] in which they have arrived at a conclusion that the vertebral level of origin of coeliac trunk ranged from upper third of T_{11} to L_2 vertebra.

Embryological elucidation: These variations in the levels of origin may be attributed to the development of ventral splanchnic arteries, which are originally paired vessels distributed to the capillary plexus in the wall of the yolk sac. They merge as unpaired trunks after the fusion of the dorsal aortae and are distributed extensively to the primitive digestive tube. The splanchnic branches then reach the dorsal border of the gut where each divides into two to embrace the gut and arrive at its ventral border. These branches form the dorsal and ventral longitudinal anastomoses Ennubli & Niveiro [10], which obviate the need of so many sub-diaphramatic ventral splanchnic arteries and hence they are reduced to three. Coeliac artery: at the level of C_7 vertebra, Superior Mesenteric artery: at the level of T3 vertebra, Inferior Mesenteric artery: at the level of T12 vertebra. Due to the descent and elongation of the gut, these arteries also descend and their level of origin changes Coeliac trunk descends ½" below T_{12} and becomes the artery of the foregut. Because of the complex development and migration of the ventral splanchnic branches, the level of origin of the coeliac trunk may vary from T_{11}-L_2 vertebrae. Though the vertebral level of origin of coeliac trunk varies very slightly the nodes lying adjacent to this vessel are at greater risk while performing surgeries for Carcinoma of stomach, pancreas and hepatobiliary tree.

BRANCHING PATTERN

In the present study, the coeliac trunk trifurcated in 90.6% and bifurcated in 9.3% of the cases. Adachi was the first person to study the anatomical variations of coeliac trunk [1]. Based on the investigations performed on 252 people of Japanese origin he formulated the Adachi's classification, which explains 6 types of division of Coeliac and superior mesenteric trunks. In this present study, hepatogastrosplenic trunk was seen in 90.6% of the cases, hepatosplenic trunk in 8%, gastrosplenic trunk in 1.3% of the cases. The results were well correlated with Adachi's study. Jerzy Gielecki claimed that all branching pattern of Coeliac trunk were not described in Adachi's classification [11]. Few studies have shown that Coeliac trunk can sometimes even divide into 5 or 6 branches [9,12,13]. Absence of Coeliac trunk and the branches arising independently from the abdominal aorta have also been reported.

Embryological explanation: Tandler provided an embryological explanation for the variations of coeliac trunk and SMA [14]. The paired dorsal aorta gives rise to a series of paired vitelline arteries, also known as primitive digestive trunks, which later forms the vessels of the digestive system. Three groups of collateral anastamotic arteries, arises during this development and named as dorsal, lateral and ventral branches. The ventral branches are initially paired vessels, which later fuse in the median line to form the four roots for the gut. These are connected by ventral longitudinal anastomosis. The Coeliac trunk is formed by the fusion of first three roots and gets separated from the fourth root. The superior mesenteric artery is developed from fourth root which later migrates caudally along

with the ventral migration of gut. Agenesis of coeliac trunk might be due to failure of the fusion of the first three roots. Persistence of these three independent roots may give rise to the three branches of the coeliac trunk, which originates separately from the abdominal aorta at different levels. The observations of the present study were also compared with various other investigators who analysed the branching pattern of Coeliac trunk [Table/Fig-7].

This study is in near agreement with Descomps, Picquand, Picquand's and Rio Branco except for the absence of coeliac axis [3,13,15,16]. Lipschutz's study showed the lowest percentage of complete coeliac axis at 72.2% highest percentage of incomplete coeliac axis at 25% and coeliaco-mesentric trunk at 2.4% [7]. None of his samples showed absence of coeliac axis. Eaton did the experiment on 206 samples and observed that 90.2% showing presence of coeliac axis while none showed absence of it [6]. A 9.2% showed incomplete coeliac axis and 0.6% showed presence of coeliaco-mesentric trunk. This current study showed similar results as Wadhwa A study with 30 cadavers in which 93.3% showed complete coeliac axis and 6.6% showed incomplete axis where both the studies did not show the presence of coeliaco-mesenteric trunk or absence of coeliac trunk [2]. Though this might be due to the small sample size, present study is in near agreement with the study of Eaton [6], whose sample size was the largest in the literature available so far. Lipschutz did a detailed study of coeliac trunk and classified his findings into 4 types based on the mode of origin and distribution of gastric, splenic and hepatic arteries [7] [Table/Fig-8].

In the present study, type I coeliac axis was found in 68 cases (90.6%) and type II coeliac axis was found in 6 (8%) cases in which the left gastric artery arose from the abdominal aorta.

Embryological explanation: This might be due to the developmental migration of one of the oesophageal branch which arises from the ventral part of the gut. Above the diaphragm, a variable number of ventral splanchnic arteries persist, usually four of five, supplying the thoracic oesophagus. Due to the rotation and migration of the gut, the artery might have got dragged along with it.

1.3% showed type IV axis in which the common hepatic artery arises directly from the abdominal aorta [Table/Fig-9].

Embryological elucidation: This might be due to an artery which developed from the ventral longitudinal anastomoses. The dorsal longitudinal anastomoses persists in the gastro-epiploic, pancreatico duodenal and primary branches of coeliac arteries, while the ventral splanchnic anastamoses forms the right and left gastric and the hepatic arteries.

Author	No of speci-men	Coeliac axis complete	Coeliac axis incomplete	Coeliaco-mesenteric trunk	Coeliac axis absent
Rossi & Cova [15]	102	86(84.5%)	12 (11.7%)	2 (1.96%)	2 (1.96%)
Descomps [3]	50	44 (87.4%)	6 (12%)	0	0
Picquand [13]	50	41 (82%)	7 (14%)	1 (2%)	1 (2%)
Rio Branco [16]	50	45 (90%)	2 (4%)	1 (2%)	2 (4%)
Lipschutz [7]	83	60 (72.2%)	21 (25%)	2 (2.4%)	0
Eaton [6]	206	186 (90.2%)	19 (9.2%)	1 (0.6%)	0
Ambica Wadhwa [2]	30	28 (93.3%)	2 (6.6%)	0	0

[Table/Fig-7]: Comparison of incidence of mode of origin of branches of coeliac trunk

Lipshutz's classification	Percentage
Type I	75%
Type II	15%
Type III	6%
Type IV	4%

[Table/Fig-8]: Lipshutz's method of classifying the coeliac trunk with percentage

[Table/Fig-9]: VRT image showing LGA arising from common hepatic artery

Author	No of specimen	Type I	Type II	Type III	Type IV
Rossi & Cova [15]	55	48 (87.2%)	6 (10.9%)	0	1 (1.8%)
Descomps [3]	50	37 (74%)	5 (10%)	3 (6%)	4 (8%)
Rio Branco [16]	50	28 (56%)	16 (32%)	0	5 (10%)
Lipschutz [7]	50	30 (60%)	15 (30%)	3 (6%)	1 (2%)
Eaton [6]	83	41 (49.3%)	21 (25.3%)	3 (3.6%)	12(14.4%)
Ambica Wadhwa [2]	206	140 (67.9%)	47 (22.8%)	10 (4.8%)	9 (4.4%)
Picquand [13]	30	28 (93.3%)	2 (6.65)	0	0

[Table/Fig-10]: Comparison of the mode of origin of branches of coeliac trunk Lipshutz's classification based on the sample size and percentage

The observations of this current study based on Lipshutz's classification of coeliac axis were compared with the works of various other investigators [Table/Fig-10].

The findings of this study correlates well with the study conducted by Rossi & Cova [15] where they reported an occurrence of Type I coeliac axis in 87.2%, Type II in 10.9% and Type IV in 14.8% and absence of Type III axis where the splenic artery occurs as a separate branch from abdominal aorta. Results were also similar to Ambica Wadhwa [2] study which showed an occurrence of 93.3% of Type I coeliac axis and 6.6% Type II axis. Lipshutz [7] reported a low percentile of Type I axis (49.3%). Incidence of Type II axis was more with 25.3% Type III and Type IV axis were 3.6% and 14.4% respectively. This difference may be due to the racial variation. Eaton [6] also reported a higher Type II percentile in his study which was 22.8%. This difference in the percentage of Type II axis may be probably due to the sample size.

CONCLUSION

These types of variations become significant in pancreatic and hepatobiliary malignancy where visualization of the surgical field can often be limited. Laparoscopic surgeries posses 15 times more risk of vascular injury than open surgery. Any delay in recognizing the bleeding in laparoscopic procedures like cholecystectomy, may result in dreaded complications like gas embolism, hypovolemic shock etc. Hence, such thorough knowledge of variant anatomy can help in selecting the treatment options, in surgical planning and avoidance of iatrogenic injury. Further study requires the course of LGA and CHA as they sometimes arise as a direct branch from the aorta. The knowledge of the abnormal course of these arteries becomes mandatory for surgeons performing gastrectomy and hepatectomy procedures.

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