

Variations in the Origin and Branching Pattern of Celiac Trunk in Cadavers of South India

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Abstract

Background: The celiac artery, also known as the celiac axis or celiac trunk, represents the initial major abdominal branch of the aorta. Various anatomical variations and accessory vessels have been documented with differing frequencies. This study aimed to investigate the pattern of the celiac trunk and its anatomical variations within a sample of the South Indian population.

Methodology: The celiac trunk was dissected in 30 fresh South Indian cadavers aged ≥ 18 years. Specimens with prior abdominal surgery, trauma, pathology, or decomposition were excluded. Variations in trunk diameter, accessory branches, and vertebral origin were recorded. The study was approved by the institutional ethics committee.

Results: In most dissections (83.3%), the celiac trunk trifurcated into the common hepatic, left gastric, and splenic arteries. Variant trifurcation occurred in one specimen, and bifurcation was absent. Additional branches were seen in 13.2% of cases, with the trunk giving rise to one or both phrenic arteries in 6.6%. Tetrafurcation and penta-furcation were each observed in 6.6%, while higher-order divisions were absent. The mean trunk diameter was 0.85 cm (range: 0.3–1.3 cm), with no significant variation across types. In 92% of cases, the celiac trunk originated between the lower border of T12 and the upper border of L1.

Conclusions: The observed frequency of celiac trunk trifurcation was lower than previously reported. A substantial proportion of cases exhibited additional vessels.

Keywords: Celiac Trunk; Celiac Artery; Celiac Axis; Anatomic Variations; Cadaveric Study; Celiac Trunk Hepta-furcation.

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Introduction

The celiac trunk (CT) is the anterior branch of the abdominal aorta, which arises at the level of the vertebral bodies of thoracic 12 (T12) to lumbar 1 (L1) and mainly supplies the foregut[1].

The celiac trunk in its regular pattern shows the existence of three terminal branches, the left gastric artery, which runs through the smaller curvature of the stomach, the splenic artery, which follows tortuous posterior superior margin of the pancreas to the spleen, and the common hepatic artery, which divides into gastroduodenal for the pancreas and duodenum vascularization, and its own hepatic

artery, which supplies the liver. This trifurcation is the typical pattern of CT present in about 89% of individuals regardless of gender. In contrast, anatomic variations of the bifurcation type occur in 11% of the population, and their absence is rare, affecting 0.2% of the individuals [2].

Anatomical variations in the origin and branching pattern of the CT are relatively common, with reported incidences ranging from 10% to 15% in the general population. These variations can have important clinical implications, particularly during surgical and radiological interventions in the upper

abdomen. Knowledge of such variations is crucial for clinicians and surgeons to avoid complications and ensure successful outcomes. Previous studies have documented various anatomical variations of the CT, including the absence of a well-defined trunk, the presence of additional branches, and different combinations of the main branches [3-6]. During the abdominal development process, the primitive arteries form three arteries related to the digestive system viscera that correspond to the celiac trunk, superior mesenteric artery, and inferior mesenteric artery. The descending longitudinal anastomoses at the front of the aorta form the omphalomesenteric artery. The anterior longitudinal anastomoses, during embryological development, namely between the future celiac trunk and the superior mesenteric artery, give rise to the embryological development of the arterial hepatic trunk. In the absence of the celiac trunk, the descending and anterior longitudinal anastomoses regress completely; however, the roots of the ventral segmental arteries do not. The 10th primitive root of the ventral segmental artery becomes the left gastric artery; the 11th becomes the splenic artery; the 12th becomes the common hepatic artery[7].

The ventral vertebral aorta and the celiac artery may often exhibit significant anatomical variations, as well as total absence of one of the branches, which may affect the surgical approaches performed, such as during organ transplantation or organ/tumor resection[8]. The absence of the celiac trunk is a rare anomaly with incidence rates varying from 0.1 to 2.6% [9,10]. Only 31 cases of missing celiac trunk were reported worldwide, and about 1/3 of these cases were detected by imaging studies, while other variations were observed during anatomical dissections[11]. The prevalence and clinical significance of these variations may vary among different populations. The present study aimed to investigate the anatomical variations

of the CT and its branches in a sample of adult human cadavers from South India.

Materials and Methods

Study Design: Observational study.

This study was conducted on 30 adult human cadavers (24 males, 06 females) in the Department of Anatomy at Kurnool Medical College, Kurnool, India. The cadavers were selected irrespective of sex and age, and the cause of death was not a factor in the selection process except death due to abdominal injury.

The abdomen was opened through a midline incision, and the coeliac trunk and its branches were carefully dissected, examined and measured using sliding calipers. The origin, course, branching pattern, and any anatomical variations were documented according to the guidelines outlined in Cunningham's Practical Manual of Anatomy (Ch. et al., 2015).

The following parameters were measured:

- Level of origin of the Celiac Trunk
- Length of the coeliac trunk
- The external diameter of the coeliac trunk
- Distance between median arcuate ligament and celiac trunk
- Branching pattern of the celiac trunk
- Distance between the superior mesenteric and coeliac arteries
- Origin of inferior phrenic arteries from celiac trunk

Statistical Analysis: The collected data was stored in electronic form in Microsoft Excel format. Chi-square test of independence was used to test association or differences in proportions for various parameters studied among the cadavers. P value of <0.05 is considered significant.

Table 1: Level of Origin of the Celiac Trunk

Level of origin	No. of specimens (n = 30)	Percentage (%)
Superior edge of T12	1	4
Inferior edge of T12	18	60
Thoracolumbar disc (T12–L1)	1	4
Upper margin of L1	10	32
Total	30	100

Table 2: Length of the Celiac Trunk

Length category (cm)	No. of specimens	Percentage (%)
< 0.6	6	20
0.6 – 1.2	7	23
1.3 – 1.8	8	27
1.9 – 2.5	4	13
Others / intermediate	5	17
Total	30	100

Table 3: Distribution of mean sex

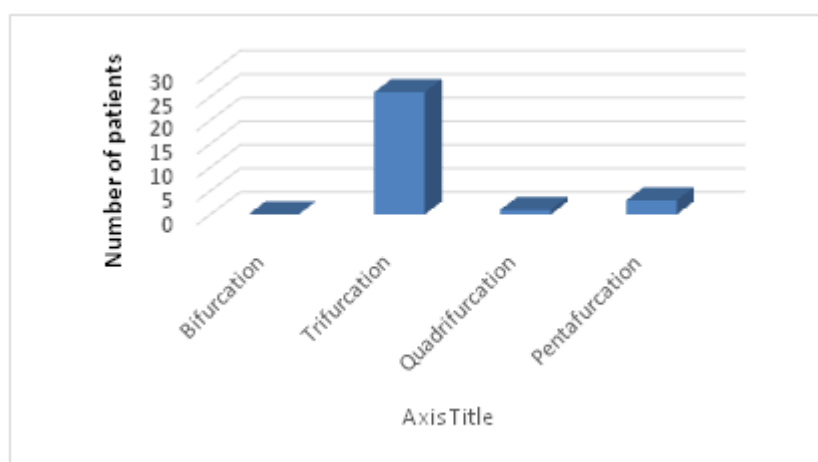
Sex	Mean $\pm$ SD (cm)	P value
Male	1.50 $\pm$ 0.42	0.1951
Female	1.20 $\pm$ 0.35	
Overall mean	1.62 cm	

Table 4: External Diameter of the Celiac Trunk at Origin

Distance range (cm)	No. of specimens	Percentage (%)
< 0.5	8	26.7
0.5 – 1.5	18	60
> 1.5	4	13.3
Total	30	100

Table 5: Branching Pattern of the Celiac Trunk

Branching pattern	No. of specimens	Percentage (%)
Bifurcation	0	0
Trifurcation	26	86
Quadrifurcation	1	3
Pentafurcation	3	10
Total	30	100

**Figure 1: Branching Pattern of the Celiac Trunk**

Results

Level of origin of the Celiac Trunk: The celiac trunk typically originates just below the diaphragmatic aortic hiatus at the lower margin of T12. In our study, we found that 60% of cadavers had the celiac trunk originating at the inferior edge of T12, 4% at the superior edge of T12, 4% at the thoracolumbar disc level, and 32% at the upper margin of L1.

A gender difference was noted: males mostly showed origins at the lower border of T12, while females more often exhibited origins at the upper border of L1.

Length of the celiac trunk: We categorized celiac trunk lengths into four groups in our study:

1. <0.6 cm,
2. 0.6-1.2 cm,
3. 1.3-1.8 cm, and
4. 1.9-2.5 cm.

The largest group (27%) had trunks measuring 1.3-1.8 cm. Six specimens (20%) were <0.6 cm, and four (13%) were between 1.9 and 2.5 cm. The mean celiac trunk length was 1.62 cm, with males averaging 1.50 cm and females 1.20 cm. Statistical analysis showed that males had a longer mean celiac trunk length than females ($P = 0.1951$). The statistical difference is insignificant.

The external diameter of the celiac trunk: The celiac trunk's external diameter at its origin was measured using sliding calipers and categorized into four groups:

1. <0.5 cm,
2. 0.5-0.7 cm,
3. 0.8-1.0 cm, and
4. 1.1-1.3 cm.

The most common group had diameters of 0.5-0.7 cm, followed by 0.8-1.0 cm (20%), 1.1-1.3 cm (10%), and <0.5 cm (7%). The mean diameter was 0.86 cm, with males and females having mean

diameters of 0.86 cm and 0.74 cm, respectively, showing no significant difference ($P = 0.6346$).

Distance between median arcuate ligament and celiac trunk: In 60% ($n=18$) of specimens, the distance between median arcuate ligament and celiac trunk ranged from 0.5 to 1.5 cm. Distances less than 0.5 cm were seen in 26.7% ($n=8$) of specimens, while 13.3% ($n=4$) had distances over 1.5 cm. The mean diameter was 0.82 cm.

Branching pattern of the celiac trunk: The celiac trunk exhibited bifurcation, trifurcation, quadrifurcation, and penta-furcation. Trifurcation was the most common pattern, occurring in 26 (86%) cases, with one atypical instance where the common hepatic, splenic, and right inferior phrenic arteries emerged from the celiac artery. Quadrifurcation was seen in 1 (3%) case, and penta-furcation in 3 (10%) cases. There was a statistically significant difference in the branching pattern between females and males ($P = 0.04$).

Discussion

Knowledge of the anatomy and dimensions of the celiac trunk and its branches is mandatory for interventional radiologists and vascular surgeons. Vascular surgeons need to know vessel dimensions and lengths to perform anastomoses and select appropriate catheter sizes for procedures such as stenting. There are numerous studies that have determined the prevalence of variations in the celiac trunk branches and the diameters of the celiac trunk and its branches[1,5,12-18].

Level of origin of the celiac trunk: The celiac trunk plays a central role in supplying blood to the liver, gallbladder, spleen, pancreas, and stomach. Our investigation aligns with prior research by Uysal et al.[19] on the anatomical position of the celiac trunk origin. Typically, the celiac trunk arises just below the aortic hiatus, near the lower margin of T12, from the abdominal aorta, and may vary between T11 and L1 due to embryonic caudal migration. An unusually high origin may cause compression by the median arcuate ligament, potentially leading to celiac artery compression syndrome.

In a study by Sehgal G et al.[20], in 45.83%, the celiac trunk originated from the junction of T12-L1, in 29.17% it originated in front of the T12 vertebra, 22.92% in front of the L1 vertebra and at the junction of T11-T12 2, 08%. In our study, we found the origin of the celiac trunk at the lower border of T12 in 60% of cases, at the upper border of L1 in 10%, and at the upper borders of L1 and T12 in 1% each.

Length of the celiac trunk: The current study revealed a celiac trunk length range of 0.4 to 2.2 cm, similar to Sehgal G et al.[20] which showed that the length ranged from 0.6 cm to 2.2 cm.

In our study, the mean celiac trunk length was 1.24 cm in males and 1.0 cm in females, with no significant intersex difference ($P=0.304$), consistent with Petrella's[21] findings. However, the mean length of the celiac trunk was reported as 2.3 cm in a previous MDCT study by Araujo Neto et al. in 2015[2] and 2.6 cm in a study on cadavers by Panagouli et al. in 2011[22]. An elongated celiac trunk may predispose to pathological conditions in surrounding tissues. Thus, patients with gastric discomfort should be evaluated for celiac compression syndrome, potentially caused by a congenitally extended celiac trunk.

External diameter of the celiac trunk: The celiac trunk diameter ranged from 0.3 cm to 1.3 cm, similar to Sehgal G et al.[20] where the trunk dimensions ranged from 4 mm to 10 mm. Most samples (58%) had diameters between 0.8 and 1.0 cm, with 4% at 0.3 cm and 2% at 1.3 cm, consistent with Saed's[23] findings in Saudi Arabia. Mean diameters were 1.30 cm for males and 1.10 cm for females, with no significant gender difference, supporting Petrella's[21] study. Accurate knowledge of arterial dimensions in populations is essential for radiological identification of arterial aneurysms.

Distance between Median Arcuate Ligament and Celiac Trunk: In our study, 18 specimens (60%) exhibited a distance between the median arcuate ligament and celiac trunk of 0.5 to 1.5 cm. Eight specimens (26.7%) demonstrated a distance of less than 0.5 cm, and four specimens (13.3%) presented a distance greater than 1.5 cm. The calculated mean distance was 0.82 cm, slightly less than the 0.94 cm reported by Petrella [21].

Branching pattern of the celiac trunk: The celiac trunk exhibited bifurcation, trifurcation, quadrifurcation, and penta-furcation similar to that observed in a study by Chitra R[24]. Trifurcation was the most common pattern, occurring in 26 (86%) cases, with one atypical instance where the common hepatic, splenic, and right inferior phrenic arteries emerged from the celiac artery. Quadrifurcation was seen in 1 (3%) case, and penta-furcation in 3 (10%) cases. There was a statistically significant difference in the branching pattern between females and males ($P = 0.04$).

Correlation of the length of the celiac trunk with its branching pattern: In our study, the length of the celiac trunk ranged from 0.2 to 2.5 cm, with greater variation in shorter trunks than in longer ones. Statistical analysis confirmed this observation, yielding a significant P value (0.001). This finding is similar to those in a study done by Suman Tiwari[25]

Conclusion

This study reveals significant variability in the anatomical characteristics of the celiac trunk, an essential artery of the foregut. Variations were found in its origin level, length, external diameter, and branching configuration, with trifurcation being the most common pattern among configurations ranging from trifurcation to pentafurcation. A notable correlation exists between short celiac trunks and atypical branching patterns. These findings highlight the prevalence of celiac trunk variations and their branching configurations, providing a crucial foundation for improving the efficacy and safety of surgical and radiological procedures in the upper abdomen. However, the sample size was small in this study, the age of the cadavers was unknown, and parameters such as height, weight, and body surface area were not collected, which are factors that could probably influence measured parameters such as arterial diameter. The factors above need to be considered for accurate results.

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