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Anatomical variations in celiac trunk in a North Indian population: A cross-sectional study using multi-detector computed tomography

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Abstract

Background: The celiac trunk is the primary arterial supply to upper abdominal organs. Anatomical variations in its branching pattern are crucial for surgical planning and interventional procedures. This study aims to analyze these variations using CECT whole abdomen scans.

Aim: To evaluate and classify celiac trunk variations using CECT imaging and assess their clinical significance.

Objectives:

- To determine the prevalence and classification of celiac trunk variations.
- To analyze their correlation with age and demographic factors.
- To assess the clinical implications of these variations in surgical and interventional procedures.

Methods: A retrospective study was conducted on 250 CECT whole abdomen scans from Department of Radiology, between 2020 and 2023. The celiac trunk anatomy was classified using Michel's and Lipshutz classifications. Data analysis included prevalence rates, age-related distribution, and statistical correlations.

Results: Among the 280 cases analyzed, 266 (95.0%) exhibited the classical trifurcation, while 14 cases (5.0%) displayed variations, including hepatosplenic trunk, gastrohepatic trunk, and other rare anomalies. The prevalence of variations was higher in patients above 50 years.

Conclusion: CECT imaging reveals significant anatomical variations in the celiac trunk, with 14.7% of cases deviating from the classical trifurcation. Preoperative identification of these anomalies is essential for improving surgical precision and reducing procedural risks.

Keywords: Celiac trunk; Anatomical variations; CECT; Abdominal vasculature; Surgical planning.

Introduction

The celiac trunk represents the initial major arterial branch of the abdominal aorta, usually originating at the level of the T12 vertebra [1]. In its classic form, it trifurcates into the left gastric artery, the splenic artery, and the common hepatic artery—referred to as the "trips Helleri" configuration [2]. However, numerous studies have highlighted that this classic branching is present in only about 70% of individuals, with a significant proportion exhibiting anatomical variations [3,4]. Such deviations include bifurcation, quadfurcation, and the presence of replaced or accessory hepatic arteries [5,6]. Recognition of these variations is critical in hepatobiliary, pancreatic, and upper gastrointestinal surgery, as well as in interventional radiological procedures [3,7]. Failure to identify variant anatomy may result in inadvertent vascular injury, ischemia, or suboptimal surgical outcomes. MDCT angiography has become the gold standard for preoperative mapping of vascular anatomy, offering high-resolution, multiplanar reconstructions that allow accurate identification of celiac axis variants [4,7,8]. Moreover, in cases of celiac artery stenosis or occlusion—often due to median arcuate ligament compression-the development of collateral pathways becomes vital for maintaining hepatic and splenic perfusion [2,9]. Detailed imaging of these pathways not only aids diagnosis but also helps in planning revascularization or stenting procedures [2,6]. The embryological basis for these variations is also well established and relates to the persistence or regression of primitive ventral splanchnic arteries during development [5,10]. Thus, a thorough understanding of celiac trunk anatomy and its variants is indispensable for safe and effective clinical practice.

Materials and methods

A cross-sectional study was carried out at the Department of Radiodiagnosis in collaboration with the Departments of Surgery and Medicine, Era's Lucknow Medical College & Hospital, Lucknow for a duration of twenty-four months. Era's Lucknow Medical College & Hospital is a tertiary care centre with state-of-the-art infrastructure catering primarily to the socio-economically underprivileged suburban and rural population of Lucknow where patients scheduled for diagnostic procedures for various medical/surgical indications referred from Departments of Medicine and Surgery comprised of the study population. Clearance for carrying out the study was obtained from the Institutional Ethical Committee Era's Medical College (Approval number: ELMC & H /RCELL, EC/2025/52), and informed consent was obtained from all the patients. The sampling frame of the study was bound by the following inclusion and exclusion criteria:

Inclusion criteria	Exclusion criteria
Adults aged 18 to 60 years referred for abdominal CT from the Department of Surgery	Impaired renal function
	Allergy to contrast media
	Previous hepatic or major abdominal surgery
	Pregnancy

The sample size was calculated at the Department of Social & Preventive Medicine, Era's Lucknow Medical College & Hospital, Lucknow. The sample size was calculated based on the proportion of cases with abnormal anatomy using the formula:

$n \geq (p(1 - p))/(ME/z\alpha)2$

Where $Z\alpha$ is value of Z at two-sided alpha error of 5%,

ME is margin of error

p is proportion of patients with normal trifurcation pattern of the celiac trunk/gastro-splenic trunk

Methodology

All the patients falling in the sampling frame and fulfilling the eligibility criteria were clinically examined and age, sex, and clinical profile were noted. Abdominal Computed tomography was performed using a 384-slice multidetector CT scanner (Som atom Force, Siemens Healthcare). Before IV contrast injection a Region of Interest (ROI) was kept over the abdominal aorta. Then Bolus of 15 ml per kg of iso-osmolar non-ionic iodinated contrast (Iohexol of 350 mg/ml) was injected into the antecubital vein at the rate of 5 ml/sec using a pressure injector followed by induction of 40 ml of saline chaser at the rate of 5 ml/sec. Images were post-processed on a workstation using Syngovia software that allowed the analysis of images. The examination was evaluated by radiologists. The origin, path and branches of Celiac trunk and Common Hepatic Artery (CHA), Splenic artery (SA) and left gastric artery (LGA) in relation with Superior mesenteric artery (SMA) and abdominal aorta was noted and classified according to Flicker's classification.

Data analysis

Data so collected were analyzed using IBM SPSS 21.0 soft¬ware. Data has been shown as numbers and percentages or mean + SD. The chi-square test was used to compare categori¬cal/discrete data. Continuous data were evaluated using inde¬pendent samples 't-test and ANOVA. A 'p-value less than 0.05 indicated a statistically significant association.

Table 1: Distribution of cases according to Celiac Trunk Variations (Uflacker's classification).

SN	Type	No. of cases	Percentage
1.	Type I	266	95.0
	Classical	240	85.7
	Non-classical	26	9.3
2.	Type II	8	2.9
3.	Type III	1	0.4
4.	Type IV	0	0
5.	Type V	4	1.4
	CHA Arising from aorta	2	0.7
	CHA Arising from SMA	2	0.7
6.	Type VI	1	0.4
7.	Type VII	0	0
8.	Type VIII	0	0

Table 2: Comparison of celiac artery anatomy between males and females.

SN	Type	Total No. of cases	Males (n=143)		Females (n=137)	
			No.	%	No.	%
1.	Normal anatomy (Type 1)	260	136	95.1	130	94.9
2.	Anatomical variations	20	7	4.9	7	5.1

Table 3: Comparison of mean age of cases with normal and variant Celiac trunk anatomy.

SN	Type	Total No. of cases	Age in years	
			Mean	SD
1.	Type I classical	240	40.28	12.61
2.	Type I non-classical	26	41.27	11.13
3.	Type II	8	41.75	12.21
4.	Type III	1	26.00	-
5.	Type V arising from aorta	2	37.00	9.90
6.	Type V arising from superior mesenteric artery	2	37.00	8.49
7.	Type VI	1	24.00	-

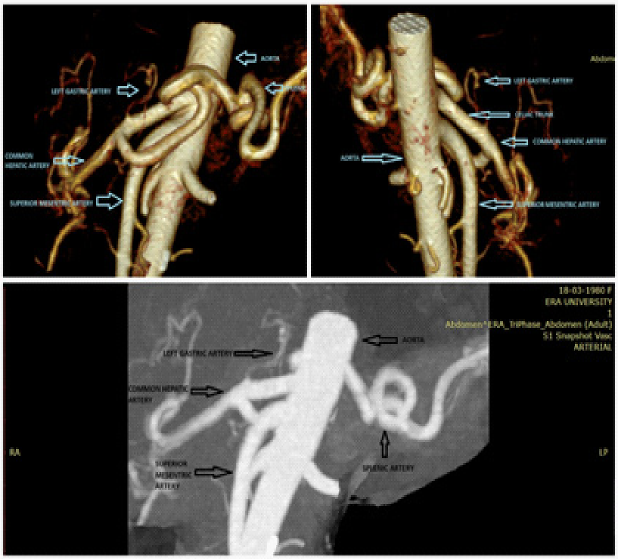

Figure 1: Type I classical Uflacker's classification.

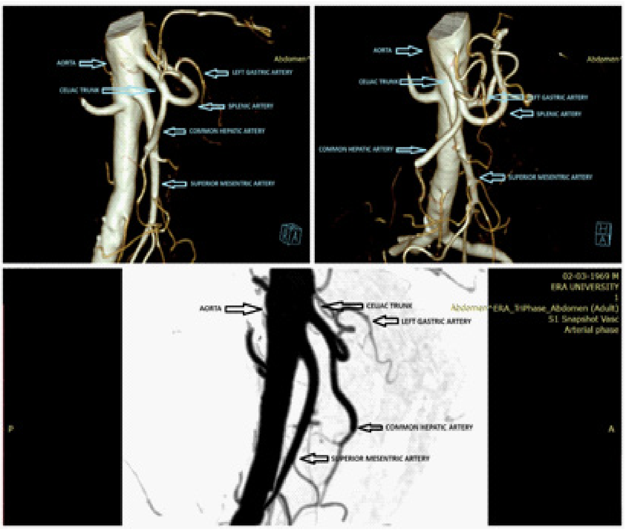

Figure 2: Type I Non-classical Uflacker's classification.

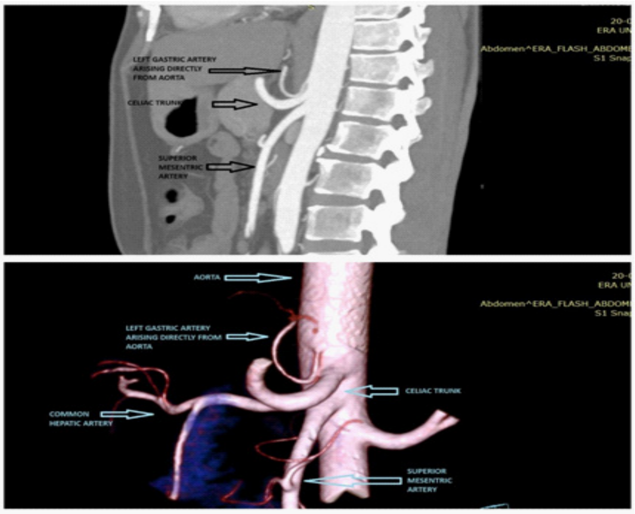

Figure 3: Type II Uflacker's classification.

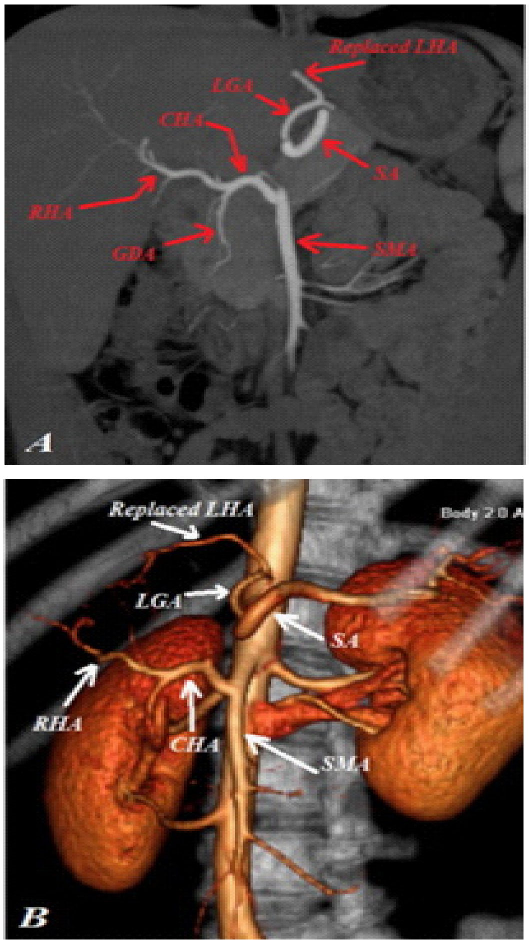

Figure 4: Type V Uflacker's classification.

Results

A total of 280 patients underwent CT angiographic evaluation of the celiac trunk using a 384-slice Siemens Force Dual Energy scanner. The age of patients ranged from 18 to 60 years, with a mean age of 40.26 ± 12.40 years. The study population included 143 males (51.1%) and 137 females (48.9%), with a male-to-female ratio of 1.04:1.

The classical trifurcation pattern of the celiac trunk (Uflacker Type I) was observed in 266 patients (95.0%). Among these, 240 patients (85.7%) had a typical trifurcation, while 26 patients (9.3%) exhibited minor deviations within Type I, including variations in branching angles and vessel calibers. Anatomical variations of the celiac trunk were identified in 14 patients (5% of the total). The distribution of these variants according to Uflacker's classification is detailed below:

No cases of Type IV, VII, or VIII were detected in the study population.

Among males, 136 cases (95.1%) demonstrated normal anatomy, and 7 cases (4.9%) had anatomical variations. Among females, 130 cases (94.9%) had normal anatomy, and 7 cases (5.1%) showed variations. There was no statistically significant association between sex and the presence of anatomical variations (p=0.934).

The mean age of patients with normal anatomy was 40.38 ± 12.46 years, and that of patients with variant anatomy was 38.00 ± 11.33 years.

No statistically significant difference was found in mean age across different variant types (p=0.733).

A significant correlation was observed between patient age and the presence of anatomical variations. Patients older than 50 years demonstrated a higher prevalence of variations (p=0.02), suggesting a possible association with vascular remodeling or increased detection due to higher imaging utilization in this age group. These observations highlight the critical need to identify celiac trunk variations before surgery, especially in hepatobiliary operations, interventional radiology, and arterial embolization, to ensure optimal clinical outcomes.

Discussion

The present study reinforces the significant anatomical variability of the celiac trunk in the population, aligning closely with the established literature. Classical trifurcation, described as the "trips Helleri" configuration, was observed in 85.7% of cases in our sample, which is consistent with rates reported in prior anatomical and imaging-based studies [1]. The remaining 14.3% displayed variations such as hepatosplenic and astrometric trunks, with rare anomalies such as celiac mesenteric trunks, underscoring the necessity for meticulous vascular mapping in preoperative planning. The incidence of hepatosplenic trunk echo the observations made by Koumaditis et al. (2023), who emphasized that such variants are among the most frequently encountered deviations from the classical anatomy [11]. These variations carry considerable surgical significance, particularly in hepatopancreatobiliary procedures where unrecognized arterial anomalies may lead to complications such as hemorrhage, ischemia, or incomplete resection. The identification of celiacomesenteric trunk in 14.3% of variant cases, though rare, bears clinical importance due to its potential involvement in pathologies such as spontaneous dissection-a condition documented in the literature as potentially life-threatening [12]. Awareness of such rare variants can guide diagnostic and therapeutic decisions, especially in emergent vascular cases. Comparative studies involving large-scale angiographic analyses have shown variation frequencies similar to ours. Koops et al. (2004), in their angiographic study of 604 patients, identified variant hepatic arterial patterns in nearly one-third of their sample, highlighting the complex spectrum of celiac axis morphology [13]. Our data further validate these statistics through CECT imaging, suggesting that advanced non-invasive imaging can reliably characterize vascular anatomy. In the South Indian population, Thangarajah and Parthasarathy (2016) reported a substantial prevalence of hepatic artery variants using MDCT, suggesting possible demographic influences on arterial configuration [14]. Similarly, our observation of a statistically significant increase in variation prevalence among patients older than 50 years might suggest age-related vascular remodeling or a detection bias due to increased imaging in this group. The implications of these findings are not merely academic. Variants of the celiac and hepatic arteries have been shown to affect surgical strategy, particularly in oncologic resections of the pancreas and liver [15]. Furthermore, the need for personalized vascular roadmaps is particularly emphasized in transplant surgeries, embolization procedures, and laparoscopic interventions. Studies such as those by Sureka et al. (2013) and Reda et al. (2021) have also emphasized the role of imaging in pre-surgical planning, reaffirming the clinical utility of MDCT angiography in delineating variant anatomy with high accuracy [16,17]. Our use of a 384-slice MDCT scanner and detailed 3D reconstructions has proven effective in detecting and classifying these variations.

Conclusion

In conclusion, the high prevalence and diversity of celiac trunk variations observed in this study underline the critical importance of individualized vascular assessment before surgical or interventional procedures. Integrating such imaging protocols into routine preoperative workflows can significantly enhance patient safety and surgical outcomes.

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