Detecting Anatomical Variations of Coeliac Trunk Branching Pattern in the Population of Karachi Using 3D Multidetector Computed Tomographic Angiography (MDCTA)

Rosheena Nabeel Khan[1], Muhammad Ali[2], Madeeha Sadiq[3], Nuzhat Hasan[4]

Abstract

Objective: To find out the frequency of variations in coeliac trunk branching pattern by Using 3D Multidetector Computer Tomographic Angiography (MDCTA),in patients referred to Radiology Department of Ziauddin University Hospital with abdominal pain, altered bowel habits, kidney or adrenal pathologies
Method: For this study, 160 individuals aged 20-60 years, without any abdominal vascular or upper abdominal visceral disease who presented to Radiology Department, Ziauddin University Hospital, Clifton Karachi, for abdominal 3D-MDCTA (3-dimensional multidetector computed tomographic angiography) from March 2017 to August 2017 were recruited in this study. It was a cross-sectional study and samples were collected through non-probability convenience sampling technique. Recruitment of study participants was done from patients who were referred to radiology department of Ziauddin University Hospital for abdominal contrast MDCTA examination due to various indications such as abdominal pain, altered bowel habits, kidney and adrenal pathologies. Persons having serum creatinine levels <1.4 mg/dl with no hepatobiliary pathologies, pancreatic or abdominal vascular lesions were included while patient having, abdominal malignancy distorting vascular anatomy, vasculitis and atherosclerosis were excluded from the study. Patients having history of liver transplant or upper abdominal surgeries or those having history of allergic reaction to contrast agents and pregnant ladies were also excluded from the study. Coeliac trunk variations were categorised according to Uflacker's classification into 8 types. Statistical analysis was done on SPSS version 20. Data is presented in percentages and frequencies.
Results: Classical coeliac trunk (type I) was present in 134 out of 160 (83.9%) individuals while 26 (16.1%) individuals showed coeliac trunk variations. Type II and type V variations were second most frequent variations i.e. in 9 (5.6%) individuals each, followed by type VII in 5 (3.6%) individuals. Type III, IV and VI showed variations in 1 (0.6%) individual each. Type VIII was not found in our sample.
Conclusion: The present study reports normal configuration of coeliac trunk i.e, classic or type I coeliac trunk in 83.9% individuals and coeliac trunk variations in 16.1% individuals.
Keywords: Celiac artery, multidetector computed tomography, laparoscopy, anatomic variations, arterio-venous anastomosis.
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Introduction

The knowledge of upper abdominal vascular anatomy is essential for radiologists and surgeons to perform various clinical, diagnostic and surgical procedures[1]. Anatomical variations of coeliac trunk are of considerable importance in liver transplants, laparoscopic surgery, penetrating injuries to the abdomen and radiological abdominal interventions[2]. Thus, it is important to have appropriate knowledge of coeliac trunk and its different variations that affect a population[3].

Coeliac trunk is the first anterior visceral branch of abdominal aorta. It arises just below the aortic hia-

[1,3,4] Department of Anatomy, Ziauddin University
[2] Department of Radiology, Ziauddin University

Correspondence: Dr. Rosheena Nabeel Khan, Department of Anatomy, Ziauddin University, Email:rosheenanabeel@gmail.com
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tus at T12/L1 vertebral level[3,4]. Coeliac trunk has three classical branches, namely, left gastric, common hepatic and splenic artery[5]. Vascular aberrations and anatomical variations of the coeliac trunk are not infrequent. Anatomic variations of coeliac trunk have been well explored in previous studies. It has been explained in previous studies that the coeliac trunk variations are embryological in origin. To the best of our knowledge only one study has been done in Pakistan, which showed anatomic variations of coeliac trunk in 11.8% individuals [6]. Our study showed a higher percentage of coeliac trunk variations i.e. 16.1% which may be due to a greater sample size in our study. A longitudinal anastomosis occurs between the four roots of vitelline arteries or omphalomesenteric artery. The central two roots disappear while a longitudinal anastomosis joins the 1st and 4th roots. The left gastric, hepatic and splenic arteries arise from this longitudinal anastomosis[7,8]. The 4th root is usually separated from the longitudinal anastomosis which forms the future superior mesenteric artery (SMA). If this separation occurs at a more proximal level, one of the branches is displaced to the SMA. If the 1st or 4th root disappears, a coeliac-mesenteric trunk is formed[7,9-11]. During embryonic period any defective fusion of omphalomessenteric arteries can manifest the variations[12].

Knowledge about the variations of coeliac trunk is of extreme clinical importance in interventional radiological, diagnostic and surgical procedures. For upper abdominal laparoscopic surgeries there is a need for exact description of coeliac trunk and its branches to avoid vascular injuries. These exact descriptions should be reported by the anatomists and radiologists so that all information can be integrated and used for the patients' wellbeing. Considerable diversity has been observed internationally in branching patternof coeliac trunk among different population and ethnic groups.

Hence, a precise knowledge of coeliac trunk branching pattern is important for following procedures. Transarterial chemoembolization (TACE), abdominal angioplasties, abdominal angiographies, for upper abdominal laparoscopic surgeries including Whipple's procedure and aortic replacement with reimplantation of coeliac trunk, there is a need for exact description of coeliac trunk and its branches to avoid ligation or division of wrong vessel which may lead to necrosis or bleeding. In gastrectomy the identification of these vascular variations also allows for precise lymph node removal, which is the most important part of gastrectomy for the treatment of gastric cancer because surgeons consider the vessels to be the landmarks in lymph node dissection. In liver transplantation there should be a complete preoperative illustration of vascular anatomy and its variations which will reduce operative morbidity during liver resection.

MDCTA has replaced conventional angiography for preoperative imaging as it is the emerging most accurate modality[13]. MDCTA has various advantages like increase in high spatial resolution, imaging acquisition speed and more coverage of the patient[14].

Multidetector computed tomography angiography (MDCTA) in association with digital images processing by software resources represents a useful tool, which is particularly attractive for its noninvasiveness[15].

Coeliac trunk variations and pathologies are relatively common occurrences. With the advent of computed tomography (CT) technology, these conditions are being diagnosed with an increased frequency even among asymptomatic individuals. CT angiography is used noninvasively for preoperative staging and vascular mapping in patients with pancreatic and hepatobiliary neoplasms. MDCTA also allows the accurate depiction of the abdominal splanchnic vessels' stenosis, collateral vessels and atherosclerotic plaques[16].

Methods

This cross-sectional study was carried out from March 2017 to August 2017. Samples was collected through Non probability convenience sampling technique. A sample size of 138 individuals was calculated by using WHO sample size calculator keeping prevalence at 10%[3,17,18], with confidence level of 95% and bound of error at 5%. Sample size was increased to 160 individuals to strengthen the results. $n = z^2P(1-P)d^2$ where n= number of samples, z= standard error of mean, P= prevalence and d= absolute precision. Total sample size160. Formula used was N= z^2pq/d^2, with Prevalence10%,Precision 0.05 and Confidence level 95%.

The study was performed on 160 individual aged 20-60 years. Recruitment of study participants was done from patients who were referred to the radiology department for abdominal contrast CT (computed tomographic) examination for various indications. Persons aged 20-60 years of both genders having serum creatinine level of <1.4mg/dl[18] with no hepatobillary pathologies, pancreatic or abdominal vascular lesionswere included in the study. Persons having hepatobillary pathologies, pancreatic or abdominal vascular lesions, or having history of liver transplant, history of upper abdominal surgeries, abdominal malignancy distorting vascular anatomy, vasculitis and atherosclerosis were excluded. Individuals having history of allergic reaction to contrast agents and pregnant ladies were also excluded from the study.

The study was conducted after approval from Ethics Review Committee of Ziauddin University. Informed consent was obtained from each participant and a questionnaire based on their demographic profile, including age, gender and medical/surgical history was filled out. MDCTA (multidetector computed tomographic angiography) of abdominal aorta was taken.

All CT examinations were performed on a 16-slice MDCT (multidetector computed tomographic) scanner (Toshiba 16 slicer Alexion, Japan) using the automatic dose modulation technique (Real Exposure Control, Toshiba Medical Systems) in the arterial phase. Contrast material was administered. The subject was asked to lie in supine position on the platform of CT scanner and was instructed to hold his/her breath for 15 seconds and then the scan was initiated.

In order to define the arterial pattern, analysis was performed in axial plane with reconstruction techniques in the coronal and sagittal planes in multiplanar reformatting images (MPR), as well as by 3D reconstruction with maximum intensity projection (MIP) and volume rendered (VR) techniques. The slice thickness was taken as 5 mm to evaluate the coeliac trunk and its branches. Images were acquired from the dome of the diaphragm to the pubic symphysis in craniocaudal fashion.

A number of classification of coeliac trunk variations have been proposed in literature. Recent literature reports the frequent use of Uflacker's classification which was proposed in year 1997[2,19]. He categorized the branching pattern of coeliac trunk variations into 8 types (Table 1) (Fig 1).

Table 1. Uflacker's Classification[1,11].

Types	Description
Type I	Classic coeliac trunk
Type II	Hepatosplenic trunk
Type III	Hepatogastric trunk
Type IV	Hepatosplenomesenteric
Type V	Gastrosplenic trunk
Type VI	Coeliac-mesenteric
Type VII	Coeliac-colic trunk
Type VIII	No coeliac trunk

Table 2. Showing the frequencies of different types of coeliac trunk in our population according to Uflacker classification[1,11,12].

Types	Description	Number (n)	(%)
Type I	Classic coeliac trunk	134	83.9
Type II	Hepatosplenic trunk	9	5.6
Type III	Hepatogastric trunk	1	0.6
Type IV	Hepatosplenomesenteric	1	0.6
Type V	Gastrosplenic trunk	9	5.6
Type VI	Coeliac-mesenteric	1	0.6
Type VII	Coeliac-colic trunk	5	3.1
Type VIII	No coeliac trunk	0	0

Data was analysed on SPSS version 20. Frequencies and percentages were calculated for coeliac trunk branching variations including classic coeliac trunk, hepatosplenic trunk, hepatogastric trunk, hepatosplenomesenteric trunk, gastrosplenic trunk, coeliac-mesenteric trunk, coeliac-colic trunk and no coeliac trunk.

Results

Out of 160 participants, the trifurcation of coeliac trunk, i.e. a classic coeliac trunk was observed in 134 (83.9%) individuals. On the contrary, anatomic

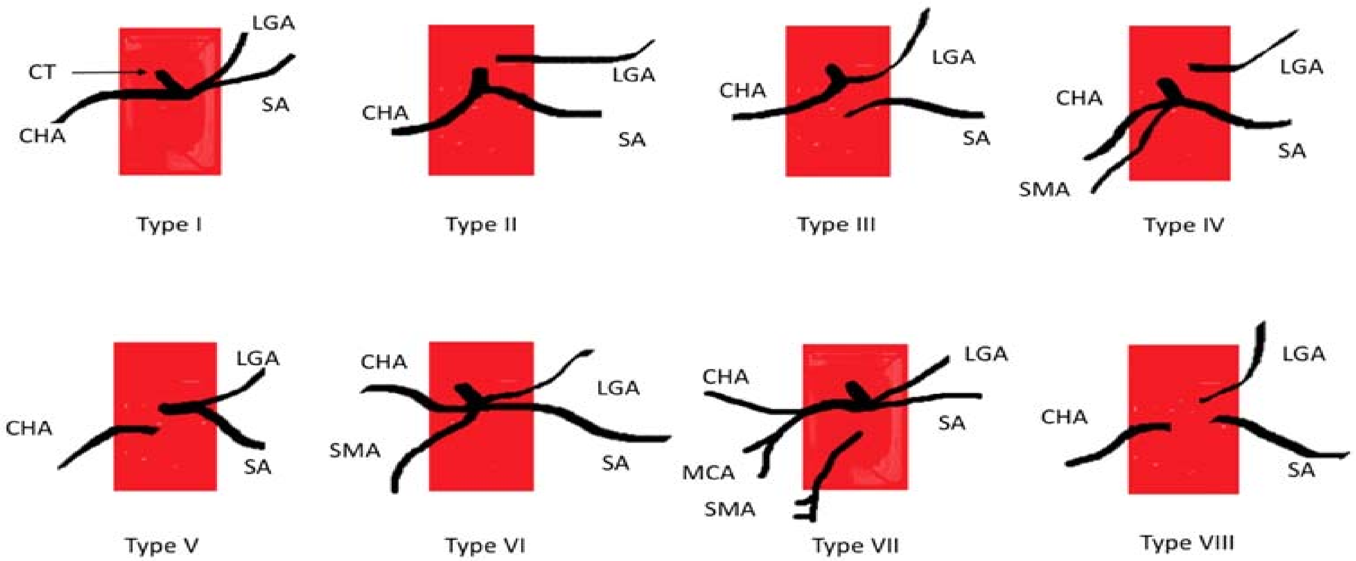

Fig. 1. Showing a schematic representation of different types of coeliac trunk variations according to Uflacker's classification[1,11]

*CT= coeliac trunk, CHA= common hepatic artery, LGA= left gastric artery, SA= splenic artery, SMA= superior mesenteric artery, MCA= middle colic artery.

variation of coeliac trunk was found in 26 (16.1%) individuals (Fig. 2).

Uflacker's classification was followed to categorise the variations. Our results showed typeII (hepatosplenic trunk) and type V (gastrosplenic trunk) to be the most frequent variations exhibiting a frequency of 9 (5.6%) each (Fig. 3). This was followed by type VII (coeliac-colic trunk showing a frequency of 5 (3.1%). Type III (hepatogastric trunk), IV (hepatosplenomesenteric trunk), and VI (coeliac-mesenteric trunk) were found to be present 0.6% i.e. 1 individual in each type. However, we did not find any case of type VIII (coeliac-colic trunk) in our sample.

Discussion

This study was aimed to examine the frequencies of variations in branching pattern of coeliac trunk according to Uflacker's classification in our population, in the hope that knowledge of these variations would help clinicians to minimize the chances of serious complications during abdominal surgeries and interventional radiological procedures.

CT scans are routinely performed pre-operatively before any laparoscopic procedure. However, the main focus of such scans is on visceral pathologies, and vascular variations are usually ignored. Lack of knowledge of these variations may lead to serious complications.

Literature suggests considerable variations in frequencies of coeliac trunk branching pattern, ranging from as low as 7.3% in the Polish population[19] to as high as 43.7% in the Russians[20]. Our results are comparable to those of many Asian populations. A study done by Babu et al. in India showed a frequency of 19.65%[21], while another study from India showed a frequency of 14%[12]. Studies done in Korea and China reported a frequency of coeliac trunk variations to be 10.9%[22] and 10.2%[17], respectively. The variations in coeliac trunk branching pattern shows diversity of frequency across populations, which is perhaps due to genetic and ethnic differences.

A classical coeliac trunk gives off 3 branches, i.e. left gastric artery, common hepatic artery and splenic artery[19]. In our study, classic coeliac trunk (Type I) was found to be present in 83.9% individuals, while anatomic variations of coeliac trunk were found in 16.1% individuals. In a cadaveric study conducted in Spain, type I was found to be presentin 90.5% individuals[23]. In another study done in Serbia

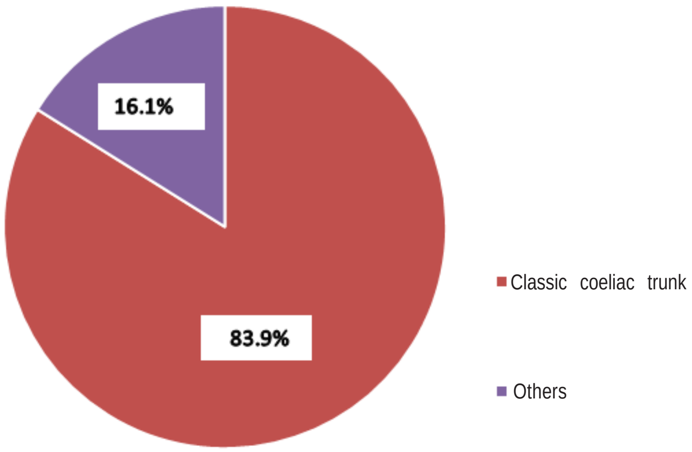

Fig. 2: Pie chart showing distribution of classic coeliac trunk and its variation in the patients referred to radiology department of Ziauddin University Hospital with abdominal pain, altered bowel habits, kidney or adrenal pathologies.

Type II denotes a hepatosplenic trunk and a separate origin of left gastric artery.Song etal.from Korea and Natsume et al. from Japan have reported comparable prevalence of type II variation, i.e. 4.4% and 4.6%, respectively[22,26].

Type V denotes a common origin of splenic and left gastric artery with an anomalous hepatic artery origin. This type of variation showed a frequency of 5.6% in our studied population. A study conducted in Pakistan showed type V as the most common variation (8.2%) of coeliac trunk[6]. An Indian study has also reported it to be the most common variation of coeliac trunk i.e. 4%[27]. However, some studies from Western populations have reported lower frequency of type II and type V. Torres et al. reported a lower frequency of type II, i.e. 2.2%, in the Polish population while Tanka et al. showed a lower frequency of type V, i.e. 1%, in Albanian population[28].

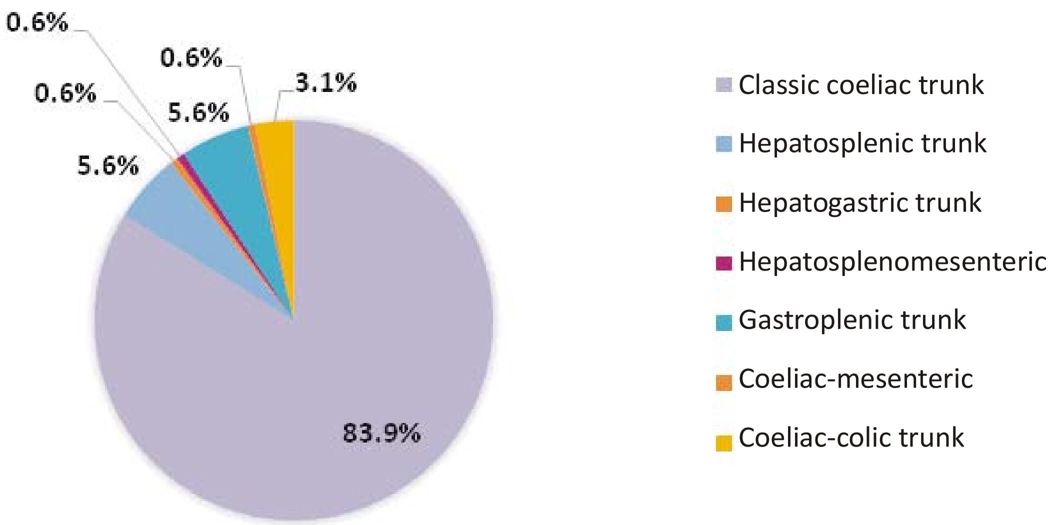

Fig 3. Prevelence ofdifferent types of coeliac trunk variations in patients referred to radiology department of Ziauddin University Hospital with abdominal pain, altered bowel habits, kidney or adrenal pathologies.

on MDCTA, type I coeliac trunk was observed in 78% individuals[24]. Presence of classic coeliac trunk pattern reduces a number of complications during surgical procedures or endovascular embolisation. A recent study in Turkey has documented 62.5% prevalence of the classical trifurcation[25].

We found type II and type V to be the most frequent variations of coeliac trunk branching pattern (5.6% each) in our sample (Fig. 2).

The second most frequent variation was found to be type VII (coeliac-colic trunk) in 3.1% of our studied population. Type VII is formed when the middle colic artery arises from the coeliac trunk instead of superior mesenteric artery. Though it has a lower frequency but it may lead to complications during transverse colon surgery[19]. In a study conducted in India, the prevalence of coeliac-colic trunk was found to be 4%[27]. We could not find the report on prevalence of coeliac-colic trunk in any other study.

In our study the frequency of type III (hepatogastric trunk), type IV (hepatosplenomesenteric trunk) and type VI (coeliac-mesenteric trunk) was found to be only 0.6% each, i.e. 1 individual in each type. Type III variation is usually found incidentally. In India, a cadaveric study conducted only on 50 samples showed the frequency of Type III to be 2%, i.e. in 1 individual only[11]. However, type III frequency has been reported as 1.7% in a Brazilian study[3]. In the Turkish population, the incidence of hepatogastric trunk has been reported to be 1%[19].

When performing pancreatic surgeries, type IV, if present, seems to be crucial. Blood supply of the duodenum may only come from the superior mesenteric artery if type IV is present. Ischemia or necrosis of the liver or duodenum may occur if there is any accidental ligation of common trunk or SMA[19]. This variation was found to be in 0.7% of cases as reported both in Korean and Japanese studies[22,29]. However, a study on the Croatian population showed a higher prevalence of type IV variation (4%)[30].

The common origin of the coeliac trunk and the superior mesenteric artery (type VI) is known as Arc of Bühler's[31]. It is extremely important to have a precise knowledge of this type of variation before planning pancreaticoduodenectomy for peri-pancreatic and pancreatic cancer treatment. In the presence of type VI variation, a peri-operative morbidity increases by 20-30%[19]. However, by the proper identification of coeliac-mesenteric trunk may help in selecting better surgical approach and may avoid iatrogenic injury and decrease the incidence of death. Type VI was found to be present only in 0.6% of our population. However, studies on Western population have reported a higher prevalence of type VI variation as compared to that reported for Asian populations. Prevalence of type VI variation in Croatia, Serbia, and in the United States of America was found to be 4%[30], 3%[24] and 3.3%[32], respectively. However, type VI variation showed very low prevalence i.e. 1.1% and 0.7% in Koreans and Japanese respectively[22,29]. A cadaveric study conducted in India did not find any case of type VI variation in their population[33].

In type VIII, no coeliac trunk is present while splenic, common hepatic and left gastric arteries arise directly from the abdominal aorta. No case of type VIII was found in our study it was also absent in an Indian study[33]. However type VIII variation has been reported as 0.1% and 1% in Polish and Turkish population respectively[2,19].

We recommend that arterial variations should be analysed carefully on CT examination preoperatively to avoid any catastrophic outcomes. Future study should be conducted on larger sample size collected from different centres of the country to have a database for Pakistani population. Limitations of this study include that the data was collected from a single tertiary care hospital.

Conclusion

The present study reports normal configuration of coeliac trunk i.e, classic or type I coeliac trunk in 83.9% individuals and coeliac trunk variations in 16.1% individuals. This supports the results of previous researches who have also reported low frequencies of coeliac trunk variations in Asian population. The anatomical variant of vascular branching pattern of coeliac trunk should be routinely reported to increase awareness among interventional radiologists and surgeons for different upper abdominal laproscopic procedures.

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Conflict of Interest

Authors have no conflict of interests and no grant/funding from any organisation for this study.

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