ORIGINAL ARTICLE

DOI: 10.4274/nkmj.galenos.2021.790720
Nam Kem Med J 2021;9(1):72-79

Morphometric Analysis of Celiac Mesenteric Trunk in Computed Tomography Images and a Review of the Literature

Bilgisayarlı Tomografi Görüntülerinde Çölyak Mezenterik Trunkusun Morfometrik Analizi ve Literatürün Gözden Geçirilmesi

Hadi SASANI

Tekirdağ Namık Kemal University Faculty of Medicine, Department of Radiology, Tekirdağ, Turkey

ABSTRACT

Aim: Evaluation of the frequency of variation and morphometric findings of the rare Celiac mesenteric trunk (CMT) in Tekirdağ province using computed tomography (CT) images.

Materials and Methods: A study population containing 1,919 patients (1,313 males, 606 females; mean age 60.47±14.88 years) with any indication of CT angiographic examination was reviewed retrospectively. The length, diameter, vertical and horizontal angles and orientations (upward, downward, right-sided, left-sided), the level of origin from abdominal aorta and their types were analyzed.

Results: Twenty-three (1.19%) CMT patients were detected. In vertical angle evaluation 20 (87%) cases had downward and three (13%) had upward orientations. In horizontal angle assessment 11 (47.8%) cases had right-sided and 12 (52.2%) had left-sided orientations. 60% of type 1 CMT cases had right-sided orientation, while 75% of type 2 cases had left-sided orientation and in both of types, the majority part had downward orientation. Fifteen (65.22%) cases were type 1 and 8 (34.78%) cases were type 2. There was a negative weak correlation between the length and diameter of CMT (p=0.048, r=-0.417). The most common level of origin of CMT was in L1-L2 level (30.4%). The most common level in type 1 was L1-L2 (40%, n=6), while L1 and L1-inferior-end-plate with the same distribution were in type 2 (37.5%).

Conclusion: In CMT, especially in terms of prior to surgical planning and arterial interventional procedures morphometric assessment is highly important. In this study, CMTs were found to be mostly type 1, as well as downward (17 degrees±14.28) and left-sided (73 degrees±6.88) orientation.

Keywords: Celiac artery, mesentery, computed tomography

ÖZ

Amaç: Bilgisayarlı tomografi (BT) görüntüleri kullanılarak Tekirdağ ilindeki nadir görülen Çölyak mezenterik trunus (CMT) varyasyon sıklığının ve morfometrik bulgularının değerlendirilmesidir.

Gereç ve Yöntem: Herhangi bir indikasyon ile BT anjiyografik incelemesi yapılan 1.919 hastayı (1.313 erkek, 606 kadın; ortalama yaş 60,47±14,88) içeren bir çalışma popülasyonu, retrospektif olarak incelendi. Uzunluk, çap, dikey ve yatay açılar ve oryantasyon (yukarı, aşağı, sağ taraflı, sol taraflı), abdominal aortadan köken aldığı düzey ve CMT tipleri analiz edildi.

Bulgular: Toplamda 23 (%1,19) CMT hastası saptandı. Dikey açı değerlendirmesinde 20 (%87) olguda aşağı, üç (%13) olguda yukarı doğru oryantasyon mevcuttu. Yatay açı değerlendirmesinde 11 olguda (%47,8) sağ taraflı, 12 olguda (%52,2) sol taraflı oryantasyon vardı. Tip 1 CMT olgularının %60'ı sağ taraflı oryantasyonlu iken, tip 2 olguların %75'inin sol taraflı oryantasyonu vardı ve her iki tipte de çoğunluğun, aşağıya doğru oryantasyonu vardı. On beş (%65,22) olgu tip 1 ve 8 (%34,78) olgu tip 2 olarak saptandı. CMT'nin uzunluğu ve çapı arasında negatif zayıf bir korelasyon vardı (p=0,048, r=-0,417). CMT'nin aortadan en yaygın orijin seviyesi L1-L2 düzeyi idi (%30,4). Tip 1'de en yaygın seviye L1-L2 (%40, n=6) iken, tip 2'de (%37,5) aynı dağılım ile L1 ve L1-alt end-plate düzeyi idi.

Sonuç: CMT'de özellikle cerrahi planlama ve arteriyel girişimsel prosedürler açısından morfometrik değerlendirme son derece önemlidir. Bu çalışmada, CMT'lerin çoğunlukla tip 1, aşağı (17 derece±14,28) ve sol taraflı (73 derece±6,88) oryantasyon olduğu bulunmuştur.

Anahtar Kelimeler: Çölyak arter, mezenter, bilgisayarlı tomografi

Address for Correspondence: Hadi SASANI MD, Tekirdağ Namık Kemal University Faculty of Medicine, Department of Radiology, Tekirdağ, Turkey
Phone: +90 282 250 74 55 **E-mail:** hsasani@nku.edu.tr **ORCID ID:** orcid.org/0000-0001-6236-4123
Received: 04.09.2020 **Accepted:** 18.01.2021

INTRODUCTION

Celiac trunk (CTR) is the major ventral vessel arising from the abdominal aorta (AA) at the level of T12, gives branches including the left gastric artery (LGA), common hepatic artery (CHA) and splenic artery. CTR with the superior mesentery artery (SMA) supplies the majority part of gastrointestinal tract and abdominal viscera[1-3]. SMA is the second major ventral branch of AA arising at the level of L1 and running down in front of the third part of the duodenum, and it supplies the small intestine.

Many variation forms of these arteries have been reported in several studies[4-7]. The Celiac mesenteric trunk (CMT), which comprises CTR and SMA, is the rarest arterial variation with the reported prevalence of 0.46-3.06%[7-12]. Determination and demonstration of these variations is highly important to detect the underlying pathology of CMT such as thrombosis-occlusion[13,14] or stenosis[13,15,16] and to prevent any undesirable complications and fatal outcomes prior to surgical and interventional vascular procedures[17-19]. Cross-sectional modalities such as computed tomography (CT) play an essential role in the diagnosis. CT is easy to apply, rapid, non-invasive imaging method with an excellent spatial and temporal resolution.

The aim of this study is to define the morphometric results of the rare CMT variation using CT images in the light of the literature.

MATERIALS AND METHODS

Study Population

Between February 27, 2017 and March 20, 2020, data of 4,024 patients with any indication and having CT angiographic examinations were scanned from hospital Picture Archive and Communication System by an eight-year experienced radiologist. From this population, 1,919 patients (1,313 males, 606 females; minimum age=18-year-old, maximum=103-year-old, mean age=60.47±14.88 years) with CT angiographic examinations including abdominal vascular structures (CTR, SMA and/or renal arteries) and those with best quality of diagnostic imaging were enrolled in the study and were reviewed retrospectively. CT examinations with poor image quality, non-abdominal CT examinations or those including pathologies affecting vascular structures (any intervention/surgery, stenosis, aneurysm, tumour) were excluded from the study.

A summary of the electronic search in the databases and algorithm of inclusion are shown in Figure 1.

Ethical Statement

This study was approved by the university/local human research ethics committee and all procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Tekirdağ Namık Kemal University Local Ethical Committee of the institution approved the study protocol (approval number: 2020.39.02.13)

Data Acquisition

CT acquisitions were performed on 128 row multi-detector CT device (Aquilion™ Prime, Canon Medical Systems).

Scanning Protocol

CT scanning parameters were as follows for each protocol: 100-250 mAs modulated by personal body mass index dose; 100-140 kV tube voltage, 0.5 mm x 80 collimation, 0.35 second gantry rotation time, 0.813 pitch factor, slice thickness 1 mm and slice interval 0.8 mm. For intravenous bolus injection of non-ionic contrast material (350 mg/100 mL, iohexol, Omnipaque®; GE Healthcare, Cork, Ireland), a mechanical injector was used at a flow rate of 4.5-5.0 mL/sec.

CT Image Assessment

An eight-year experienced radiologist retrospectively analysed the CT images and assessed all of the morphometric measurements (diameter, length, angle and orientation classification of CMTs).

CMT Morphologic Analysis

The length, diameter, and vertical and horizontal angles as well as vertical orientation (upward, downward) and horizontal orientation (right or left-sided) were analysed morphologically. The length of CMT was measured from the trunk's outlet till branching level. Vertical and horizontal angles were measured as the angle between the artery outside border and the horizontal plane line (angle of emergence). CMTs were categorized depending on their locations, orientation and the level of origin from the AA. The diameters of CMTs were measured both on sagittal and coronal planes craniocaudally (Figure 2).

In addition, type classification of CMT cases was evaluated according to the classification by Tang et al.[11]. CMT was classified into five types:

Type 1: Hepato-gastro-spleno-mesenteric trunk,

Type 2: Hepato-spleno-mesenteric trunk with the LGA arising from the AA,

Type 3: Gastro-spleno-mesenteric trunk with the CHA arising from the AA, Type 4: Hepato-gastro-mesenteric trunk with the splenic artery arising from the AA,

Type 5: Any other variation that meets the above definition of the CMT (LGA originating from other arteries except the AA, CTR and single common trunk; the CHA arising from the SMA).

Statistical Analysis

Statistical package program (SPSS version 17, Chicago, USA) was used in analysing data. The variables were investigated using visual (histograms, probability plots) and analytical methods to determine whether they were normally or not normally distributed. Investigating the associations between non-normally distributed and/or ordinal variables, the correlation coefficients and their significance were calculated using the Pearson test. Descriptive statistics were used in data analysis. A 5% type 1 error level was used to infer statistical significance.

RESULTS

CMT Cases

Among the patient population having CT angiographic examinations (n=1919), 23 (1.19%) cases were detected to be CMT. Of 23 cases, 20 (87%) were male and three (13%) were female, with the mean age of 57.4±16.62 years (range: 18-83 years).

Morphometric Analysis

The mean length of the CMT was 25.35±9.13 (range: 7.6-38 mm), the mean diameter of CMT was 12.06±2.12 mm (range: 8.5-15.6 mm), the mean vertical and horizontal angles were 18.48±14.16 degrees (range: 0.8-51.3 degrees) and 73.65±10.74 degrees (range: 54-103.4 degrees), respectively.

A negative weak correlation was found between the length and diameter of CMT (p=0.048, r=-0.417) (Figure 3).

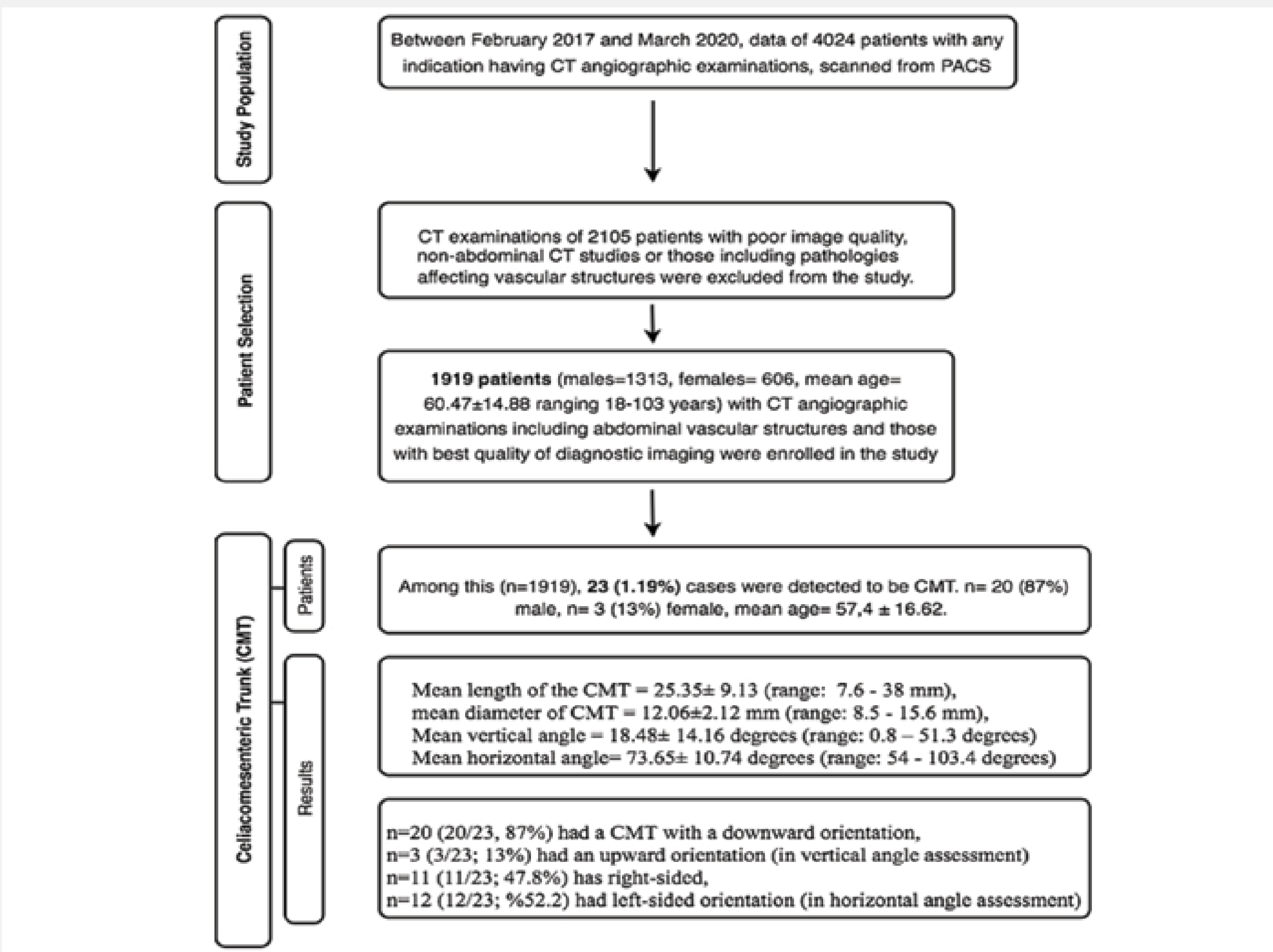

Figure 1. The flow chart diagram of the study

CT: Computed tomography, PACS: Picture Archiving and Communication Systems

In vertical angle assessment of 23 patients, 20 patients (20/23; 87%) had a CMT with a downward orientation and three patients (3/23; 13%) with an upward orientation. Eleven (11/23; 47.8%) of the patients had a CMT with right-sided and 12 (12/23; 52.2%) with a left-sided orientation in horizontal angle assessment.

The mean vertical angle with downward and upward orientations were found as 17±14.28 degrees and 28.56±9.61 degrees, respectively. The mean horizontal angle with right-sided and left-sided orientations were found as 74.44±14.16 degrees and 73±6.88 degrees, respectively.

In CMT population, 15 (65.22%) patients were detected to be type 1 and 8 (34.78%) patients were type 2, respectively (Figure 4). Although there was male preponderance in both of types, type 1 was the most common type in the male population (n=14, 93.3%), while type 2 was the most common in the females (n=2, 25%). Sixty percent (n=9) of type 1 CMT patients tended to have right-sided orientation, while 75% of type 2 CMT patients (n=6) had a tendency of left-sided orientation. In both of types, the majority parts of CMT population (type 1: n=13, 87.6%; type 2: n=7, 87.5%) showed to have downward orientation (Table 1).

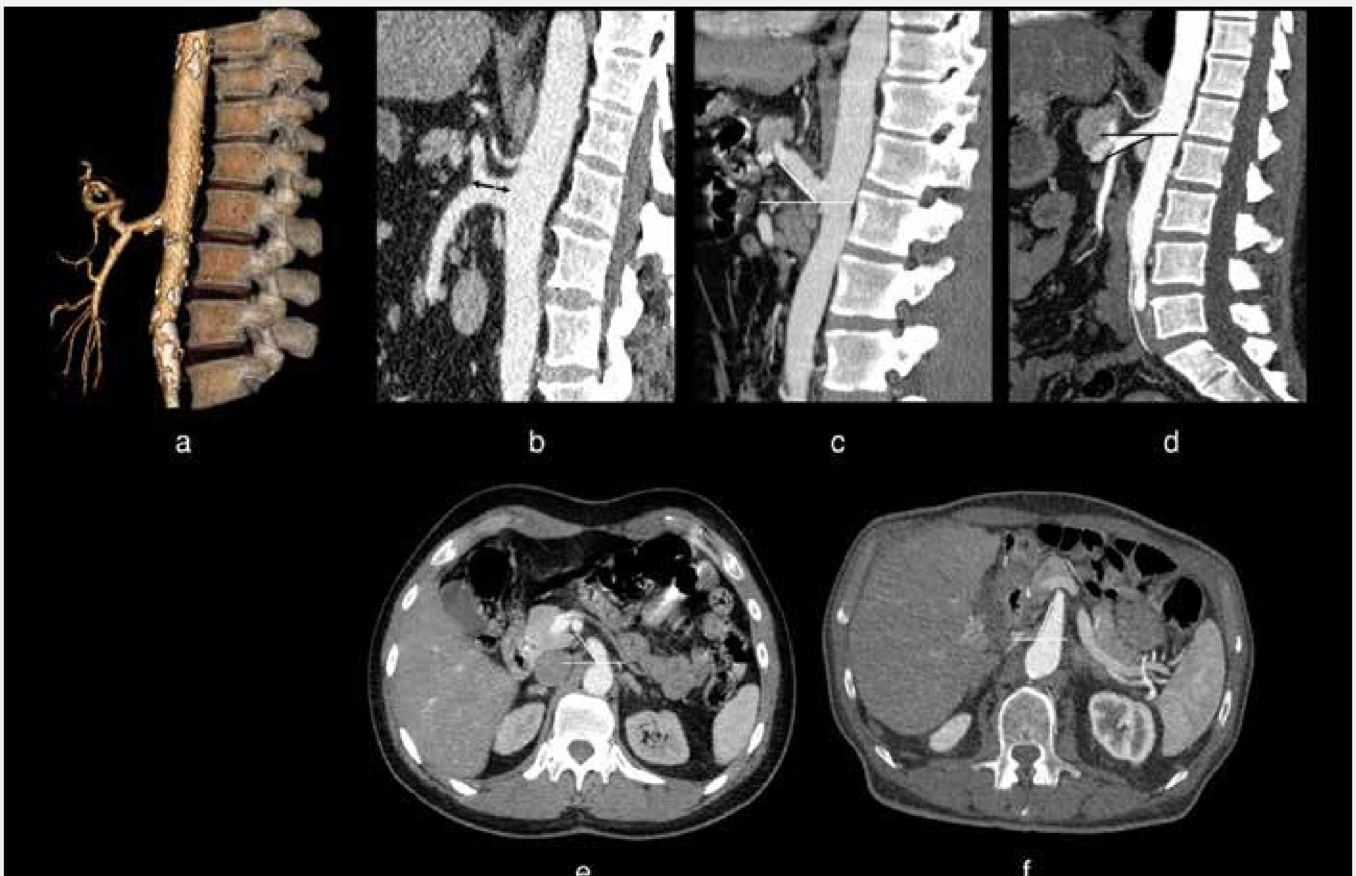

Figure 2. Morphometric evaluation of Celiac mesenteric trunk (CMT) population. (a) 3D reformat image of a CMT case, (b) measurement of the length (black double headed arrow) and diameter (white double headed arrow) of the CMT; vertical angles or angle or emergence: (c) upward orientation and (d) downward orientation; horizontal angles (e) right-sided orientation and (f) left-sided orientation

Table 1. The number of Celiac mesenteric trunk cases according to the types and orientations

Type	Vertical orientation		Total	Transvers orientation		Total n (%)
	Downward n (%)	Upward n (%)	n (%)	Right-sided n (%)	Left-sided n (%)	
Type 1	13 (86.7%)	2 (13.3%)	15 (100.0%)	9 (60.0%)	6 (40.0%)	15 (100.0%)
Type 2	7 (87.5%)	1 (12.5%)	8 (100.0%)	2 (25.0%)	6 (75.0%)	8 (100.0%)
Total	20	3	23	11	12	23

The distribution of CMT origin levels was most common in L1-L2 (30.4%, n=7), followed by L1 (26.1%, n=6) and with the same number of patients in T12-L1 and L1- inferior-end-plate level (21.7%, n=5), respectively. The level of origin in type 1 was detected to be most common in L1-L2 level (40%, n=6) and the level of origin in type 2 was mostly at both levels in the L1 and L1-inferior-end-plate (37.5%, n=3). Type 1 was the most dominant type (65.2%, n=6) among all of the levels (T12-L1, L1, L1-inferior- end-plate and L1-L2), while type 2 was dominant only in L1-inferior-end-plate level (60%, n=3). L1-L2 level was the most common level of origin in male population (35%, n=7), while L1 was the most common level in females (66.7%, n=2) (Table 2).

DISCUSSION

In the literature, some studies reported the variations of CTR and CMT with different range of incidence[7-12] and quantitative measurements (length, diameter, type and level of origin, angle)[8,11,19-22]. In the current study, unlike the literature, both vertical and horizontal orientations, angles of CMTs and their relationship with their types have been analysed. In the present study, the incidence of CMT was found to be 1.2% in Tekirdağ province and more attention should be paid to CMT vascular evaluation. It is more common for CMT variation to be longest type, type 1, L1 output-level and downward orientation, and these parameters should be considered in vascular surgery or interventional procedures to be performed in the population in this region.

During embryonic period, the 10th to 13th vitelline arteries communicate between the aorta and a primitive ventral

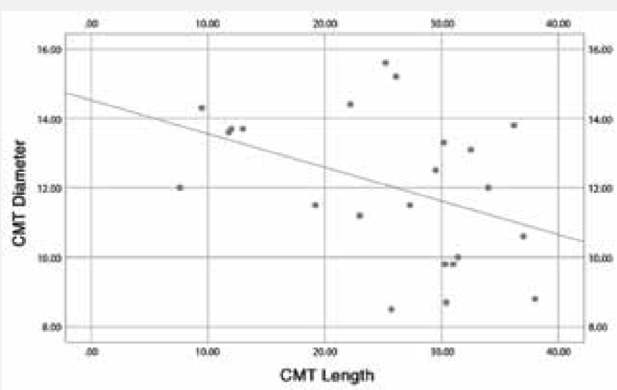

Figure 3. A negative weak correlation between the length and diameter of Celiac mesenteric (p=0.048, r=-0.417)

CMT: Celiac mesenteric trunk

Figure 4. Celiac mesenteric trunk (CMT) types: (a) coronal (b) sagittal 3D reformat computed tomography (CT) images of CMT type 1 (hepato-gastro-spleno-mesenteric trunk); (c) coronal (d) sagittal 3D reformat CT images of CMT type 1 (hepato-spleno-mesenteric trunk with left gastric artery arising from the abdominal aorta)

Table 2. Distribution of Celiac mesenteric trunk cases by origin level and types

			Level of origin				Total
			T12-L1	L1	L1 inferior-end-plate	L1-L2	
Type	Type 1	(n)	**4**	**3**	**2**	**6**	**15**
		Type (%)	26.7	20.0	13.3	40.0	100.0
		Level of origin (%)	80.0	50.0	40.0	85.7	65.2
	Type 2	(n)	**1**	**3**	**3**	**1**	**8**
		Type (%)	12.5%	37.5%	37.5%	12.5%	100.0%
		Level of origin (%)	20.0%	50.0%	60.0%	14.3%	34.8%
Total		(n)	**5**	**6**	**5**	**7**	**23**
		Type (%)	21.7%	26.1%	21.7%	30.4%	100.0%
		Level of origin (%)	100.0%	100.0%	100.0%	100.0%	100.0%

anastomotic artery. The regression of the ventral anastomosis and vitelline arteries (11th and 12th) and the persistence of the 10th and 13th roots provide giving origin to the CTR and the SMA. When the 10th to 12th vitelline arteries regress and a large portion of the ventral anastomosis persists (13th), CMT occurs (Figure 5)[23].

There are some classifications about CTR variations available in the literature. Lipshutz[24] suggested a classification of CTR into four types in 1917, and Adachi et al.[25] classified more detailed anatomical variation of CTR and SMA in six types in 1928. Followed by Morita[26], Michels[27] and Uflacker[28] presented their classifications. In the recent work by Tang et al.[11], they have focused on the classification of CMT variation. In the current study, CMT type 1 according to Tang classification is compatible with Adachi type 4, and Tang type 2 is compatible with Adachi type 3.

Although gender and race had an effect on the presence or absence of variations in CTR[5], most studies[5,29,30] revealed that it had only relationship with ethnicity and origin of the study population, not with gender. According to the literature, Japanese, Caucasian, Korean, Indian and black-coloured populations have more variations of CTR, respectively[5]. On the other hand, in a meta-analysis including 36 studies (total subjects n=17,391) from fourteen countries and four continents, there was a preponderance of males (male/female ratio of 2.36:1). The pooled prevalence estimates of variant CTR with 95% confidence interval depending on the geographical region were mostly found in South America (0.3340) followed by Europe, West Asia, Africa and West Asia, respectively[12]. To date, the highest incidence of CMT has been reported as 3.06% in 171 CMT patients[11]. The incidence of CMT in the current study was detected to be 1.2%.

The length of CTR varies between 8 and 40 mm[8]. In the study by Tang et al.[11], they divided 171 CMT patients into long-type (17-39 mm) and short-type (6-14 mm) CMT groups. The long type (61.99%) was more common than the short type. In the current study, CMT length was ranging from 7.6 mm to 38 mm; similarly, the longest type (n=18; mean value=29.4 mm±5.2, range: 19.2 mm-38 mm) was more common than the shortest-type (n=5; mean value=10.78 mm±2.19, range: 7.6 mm-11.8 mm).

In the study by Tang et al.[11], the most common type was found to be type 1 that was accounting for 56.14%, followed by type 2 33.33%, type 3 2.34%, and type 4 1.75%. Similarly, in the

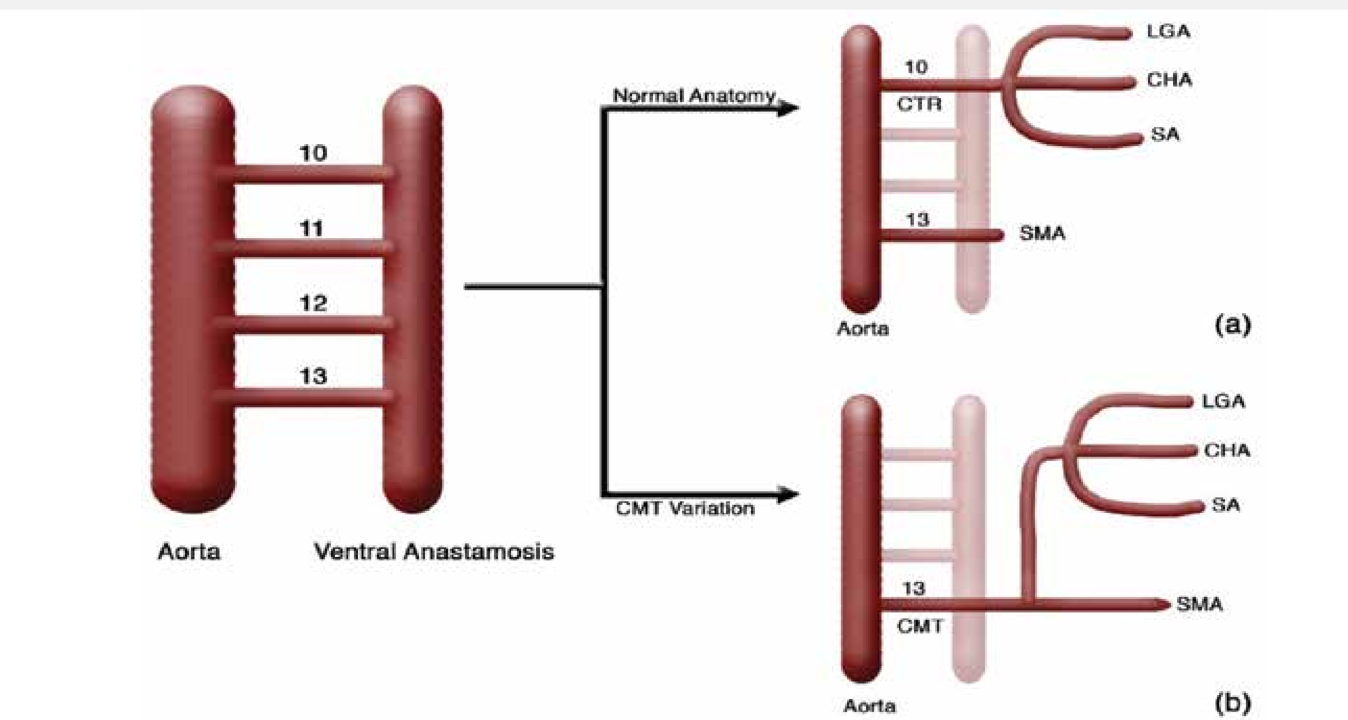

Figure 5. Embryological development of normal mesenteric vascular structures and the Celiac mesenteric trunk (CMT). (a) The 10th-13th vitelline arteries communicate between the aorta and a primitive ventral anastomotic artery (b) When the 10th to 12th vitelline arteries regress and a large portion of the ventral anastomosis persists (13th), CMT occurs

*CHA: Common hepatic artery, LGA: Left gastric artery, SA: Splenic artery, CTR: Celiac trunk, SMA: Superior mesenteric artery, *: Liver segment 4A feeding artery* current study, the most common type was type 1 (65.22%) followed by type 2 (34.78%).

The diameter of CTR has been reported to range from 6.61±1.67 mm to 8±0.9 mm in some studies in the literature[19,20,22]. In another study, the mean diameter of CTR was measured as 6.22 mm (ranging from 5.4 mm to 7.3 mm) and the mean diameter of CMT was 8.42 mm (ranging from 5.2 mm to 11.6 mm)[10]. In the study on 155 adult cadavers, it was found that the length of CTR increased quickly until the age of 20 years (in new-borns ranging from 3 mm to 8 mm; in adults ranging from 15 mm to 54 mm), while the diameter of CTR increased by the age (new-borns: 1.5-2.0 mm, adults: 3.1-4.3 mm). Also, she mentioned the measured diameter and the length of CTR in pyknics (obese or rounded body structure) were found to be larger (length: 12-29 mm), while in leptosomes (thin body structure), the diameter was smaller (3.1 mm), but the length was greater (39-54 mm)[21]. In the current study, the mean diameter of CMT was measured as 12.06±2.12 mm and a statistically weak negative correlation was found between the CMT length and diameter (p=0.048, r=-0.417), which means that CMT diameter increases as length decreases (Figure 3).

Although the CTR had various levels of origin ranging from the T11 to L1 vertebra, the most common level was found to be T12–L1 (45.83%) followed by T12 (29.17), L1 (22.92) and T11-T12 (2.08%), respectively[1]. Selvaraj and Sundaramurthi[2] reported the similar findings of CTR origin levels that were T12-L1 (70.7%), L1 (18.6%) and T12 vertebra (10.7%), respectively. In the study by 10 CMT patients, the most common level of origin was found to be L1 (30%); T12-L1, L1 end-plate level, L1-L2 (20%) and T12 (10%), respectively[10]. The originating level of CTR in pyknics tended to be higher, while in leptosomes, it was lower [21]. In the current study, as shown in the Table 2, the most common level of CMT origin in type 1 was found to be L1-L2 (40%, n=6), followed by T12-L1 level (26.7%, n=4); and in type 2, it was in both L1 and L1-inferior-end-plate levels with the same counts (37.5%, n=3).

The angle between CTR and AA was studied in some literatures[10,31]. The angle of emergence of CTR was reported to be less than 90 degrees, ranging from 7 to 83 degrees. Before the first branch, there was an upward shift in 95% (n=306) and downward shift in 4.36% (n=14) of 321 patients. In one patient, CTR remained straight[31]. In another study in CMT patients, in the sagittal plane, the mean angle between the CMT and AA was measured as 26.65 degrees ranging from 13.5 to 38 degrees[10]. The angle of CTR in pyknics was greater measuring between 106 and 115 degrees; in contrast, it was smaller (<73 degree) in leptosomes[21]. In the current study, both vertical and horizontal angles were studied and found to be 18.48±14.16 degrees and 73.65±10.74 degrees, respectively. The majority part of the patients was constituted with those with downward orientation (87%, n=20) in vertical angle and had left-sided orientation in horizontal angle (52.2%, n=12) assessment. Both of the reports[10,31] have studied only vertical angle between CMT and AA in which the values are in the similar ranges but none has studied the horizontal angle.

The direction of CTR is influenced by the origin of the hepatic artery and the topography of the pancreatic neck. If CTR is not the origin of the hepatic artery (gastrosplenic trunk), it is directed to the left side, attending as the splenic artery[32]. Although underdevelopment of rightward component is observed in new-borns, it is the hepatic artery that pulls CTR to the right-side[33,34].

It is very important to know other underlying diseases or pathologies associated with CMT. Aneurysm[15], stenosis[16], thrombosis[13,14], mesenteric ischemia[13,16], arterial compression (egg. median arcuate ligament syndrome)[15] and nutcracker syndrome[35] can be associated with CMT which may have important results and may affect the survival specially in the occlusive diseases[13]. Here, CT plays an important role in the detection of variation. Also, as a new technique, cinematic rendering with random sampling computational algorithms and different light maps provides a realistic depiction of anatomical details from CT data[36].

Study Limitations

The limitation of the study was that it was conducted with few patients (23 CMTs of 1919 patient population) having CT angiographic examinations. Although the incidence of variation is rare, the patient population participating in this study has the largest patient population included in the studies across the country. However, due to only three female patients, there was not a homogeneous sample group in this study. Due to the retrospective nature of the study, the patients could not be classified in their morphology as leptosomes or pyknics.

CONCLUSION

Having knowledge about arterial variations such as CMT is very important for both surgical approach and planning of interventional procedures and management of CMT-related pathologies. Particularly in vascular interventions, morphometric features of the arterial structures are most of value. As a result, in this study, CMT was found to be mostly type 1, as well as downward (17 degrees±14.28) and left-sided (73 degrees±6.88) orientation.

Ethics

Ethics Committee Approval: Tekirdağ Namık Kemal University Local Ethical Committee of the institution approved the study protocol (approval number: 2020.39.02.13).

Informed Consent: Retrospective study.

Peer-review: Externally peer-reviewed.

Financial Disclosure: The author declared that this study received no financial support.

References

1. Sehgal G, Srivastava AK, Sharma PK, Kumar N, Singh R, Parihar A, et al. Morphometry of the celiac trunk: a multidetector computed tomographic angiographic study. Journal of the Anatomical Society of India. 2013;62:23-7.
2. Selvaraj L, Sundaramurthi I. Study of Normal Branching Pattern of the Coeliac Trunk and its Variations Using CT Angiography. J Clin Diagn Res. 2015;9:AC01-4.
3. Standring S. Gray's Anatomy. 39th ed. Edinburgh; New York, NY: Elsevier Churchill Livingstone; 2005.
4. Santos PVD, Barbosa ABM, Targino VA, Silva NA, Silva YCM, Barbosa F, et al. Anatomical Variations of the Celiac Trunk: A Systematic Review. Arq Bras Cir Dig. 2018;31:1403.
5. Panagouli E, Venieratos D, Lolis E, Skandalakis P. Variations in the anatomy of the celiac trunk: A systematic review and clinical implications. Ann Anat. 2013;195:501-11.
6. Song SY, Chung JW, Yin YH, Jae HJ, Kim HC, Jeon UB, et al. Celiac axis and common hepatic artery variations in 5002 patients: systematic analysis with spiral CT and DSA. Radiology. 2010;255:278-88.
7. Yi SQ, Terayama H, Naito M, Hayashi S, Moriyama H, Tsuchida A, et al. A common celiacomesenteric trunk, and a brief review of the literature. Ann Anat. 2007;189:482-8.
8. Cavdar S, Sehirli U, Pekin B. Celiacomesenteric trunk. Clin Anat. 1997;10:231-4.
9. Obara H, Matsumoto K, Fujimura N, Ono S, Hattori T, Kitagawa Y. Reconstructive surgery for a fusiform common celiomesenteric trunk aneurysm and coexistent abdominal aortic aneurysm: report of a case. Surg Today. 2009;39:55-8.
10. Ozgokce M, Ayyıldız VA, Ogul H, Arslan H, Batur A, Yavuz A, et al. Common coeliacomesenteric trunk: a computed tomography radiological study. Folia Morphol (Warsz). 2018;77:683-6.
11. Tang W, Shi J, Kuang LQ, Tang SY, Wang Y. Celiomesenteric trunk: New classification based on multidetector computed tomography angiographic findings and probable embryological mechanisms. World J Clin Cases. 2019;7:3980-9.
12. Whitley A, Oliverius M, Kocián P, Havlůj L, Gürlich R, Kachlík D. Variations of the celiac trunk investigated by multidetector computed tomography: Systematic review and meta-analysis with clinical correlations. Clin Anat. 2020;33:1249-62.
13. Kueht ML, Wu DL, Mills JL, Gilani R. Symptomatic Celiomesenteric Trunk: Variable Presentations and Outcomes in 2 Patients. Tex Heart Inst J. 2018;45:35-8.
14. Lovisetto F, Finocchiaro De Lorenzi G, Stancampiano P, Corradini C, De Cesare F, Geraci O, et al. Thrombosis of celiacomesenteric trunk: report of a case. World J Gastroenterol. 2012;18:3917-20.
15. Lee V, Alvarez MD, Bhatt S, Dogra VS. Median arcuate ligament compression of the celiomesenteric trunk. J Clin Imaging Sci. 2011;1:8.
16. Ratra A, Campbell S. Recurrent Mesenteric Ischemia from Celiomesenteric Trunk Stenosis. Cureus. 2018;10:2751.
17. Pannatier M, Duran R, Denys A, Meuli R, Zingg T, Schmidt S. Characteristics of patients treated for active lower gastrointestinal bleeding detected by CT angiography: Interventional radiology versus surgery. Eur J Radiol. 2019;120:108691.
18. Prakash, Mokhasi V, Rajini T, Shashirekha M. The abdominal aorta and its branches: anatomical variations and clinical implications. Folia Morphol (Warsz). 2011;70:282-6.
19. Songür A, Toktaş M, Alkoç O, Acar T, Uzun İ, Baş O, et al. Abdominal Aorta and Its Branches: Morphometry - Variations In Autopsy Cases. Eur J Gen Med. 2010;7:321-5.
20. Best IM, Pitzele A, Green A, Halperin J, Mason R, Giron F. Mesenteric blood flow in patients with diabetic neuropathy. J Vasc Surg. 1991;13:84-9.
21. Kozhevnikova TI. Individual'nye i vozrastnye osobennosti v stroenii chrevnogo stvola cheloveka [Age and individual characteristics in the structure of the celiac trunk in man]. Arkh Anat Gistol Embriol. 1977;72:19-25.
22. Silveira LA, Silveira FB, Fazan VP. Arterial diameter of the celiac trunk and its branches. Anatomical study. Acta Cir Bras. 2009;24:43-7.
23. Walker TG. Mesenteric vasculature and collateral pathways. Semin Intervent Radiol. 2009;26:167-74.
24. Lipshutz B. A Composite Study of the Coeliac Axis Artery. Ann Surg. 1917;65:159-69.
25. Adachi B, Hasebe K, Kyōto Teikoku Daigaku, Kenkyūsha, History of Medicine Collection (David M. Rubenstein Rare Book & Manuscript Library), Paul Kligfield Collection (David M. Rubenstein Rare Book & Manuscript Library). Das Arteriensystem der Japaner. 1928.
26. Morita M. Reports and conception of three anomalous cases on the area of the celiac and the superior mesenteric arteries. Igaku Kenkyu (Acta Med). 1935;9:1993-2006.
27. Michels N. Blood supply and anatomy of the upper abdominal organs, with a descriptive atlas. J.B. Lippincott Company, Philadelphia; 1955.
28. Uflacker R. Atlas of Vascular Anatomy: An Angiographic Approach. 1st ed. Philadelphia PA: Lippincott Williams & Wilkins; 1997.
29. Chen H, Yano R, Emura S, Shoumura S. Anatomic variation of the celiac trunk with special reference to hepatic artery patterns. Ann Anat. 2009;191:399-407.
30. Venieratos D, Panagouli E, Lolis E, Tsaraklis A, Skandalakis P. A morphometric study of the celiac trunk and review of the literature. Clin Anat. 2013;26:741-50.
31. Petnys A, Puech-Leão P, Zerati AE, Ritti-Dias RM, Nahas WC, Neto ED, et al. Prevalence of signs of celiac axis compression by the median arcuate ligament on computed tomography angiography in asymptomatic patients. J Vasc Surg. 2018;68:1782-7.
32. Vandamme JP, Bonte J. Vascular anatomy in abdominal surgery. 1st ed. New York, NY: Thieme Medical Pub; 1st edition. Jan 15, 1990.
33. Gielecki J, Zurada A, Sonpal N, Jabłońska B. The clinical relevance of coeliac trunk variations. Folia Morphol (Warsz). 2005;64:123-9.
34. Saeed M, Murshid KR, Rufai AA, Elsayed SE, Sadiq MS. Coexistence of multiple anomalies in the celiac-mesenteric arterial system. Clin Anat. 2003;16:30-6.
35. Peterson J, Hage AN, Diljak S, Long BD, Marcusa DP, Stribley JM, et al. Incidental Anatomic Finding of Celiacomesenteric Trunk Associated with 'Nutcracker Phenomenon,' or Compression of the Left Renal Vein. Am J Case Rep. 2017;18:1334-42.
36. Dappa E, Higashigaito K, Fornaro J, Leschka S, Wildermuth S, Alkadhi H. Cinematic rendering - an alternative to volume rendering for 3D computed tomography imaging. Insights Imaging. 2016;7:849-56.