AFGHAN MEDICAL JOURNAL
KABUL UNIVERISITY OF MEDICAL SCIENCES ABU ALI IBN SINA
Vol 1, Issue 2 | November 2024 AMJ e-ISSN: 3007-0805

CELIAC TRUNK VARIATIONS IDENTIFICATION USING MULTI-DETECTOR COMPUTED TOMOGRAPHIC IMAGING

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Abstract

Background: Variability in the celiac trunk is frequent and should be taken into consideration when scheduling surgical operations or radiographic intervention, in order to minimize the possibility of unintentional damage to the blood vessels. The objective of this study was to estimate the prevalence of celiac trunk and identify various types of the existed variations using multi-detector computed tomographic angiography.

Method: A cross-sectional study which was retrospective had been carried out. Images from the computed tomographic angiography were obtained between June 2017 and March 2018. Using a workstation, 3D reconstructions of the images were made and the normal and anatomical variations of the celiac trunk were examined. IBM SPSS statistic version 22 was utilized to calculate the results.

Findings: Out of the 140 patients who were chosen, 23 were not included. With a male to female ratio of 65.8 to 34.2, the average age was 57.3 years. In 54 (46.2%) cases, anatomical variations of the celiac trunk were identified. In 21 cases (17.9%), the origin of the inferior phrenic artery from the celiac trunk was the most prevalent variation, followed by the celiac-colic trunk in 15 cases (12.8%). Nonetheless, some variations which were not included in Uflacker's classification were also seen in 31 (26.5%) of the cases. The association of the inferior phrenic artery with other Uflacker's types, the Buhler arc, the accessory hepatic artery from the celiac trunk, and the association of the celiac-colic trunk with the gastro-splenic and hepato-splenic trunks are among the variations which were identified.

Conclusion: Before having any surgery or invasive imaging intervention, it is important to accurately identify and understand the structural variations in the celiac trunk. This can assist interventional radiologists and surgeons in carrying out safe procedures and preventing unintentional vascular damage.

Keywords: accessory hepatic artery, anatomical variation, celiac trunk, common hepatic artery, MDCTA

1. INTRODUCTION

Celiac trunk (CT) is the first visceral branch of abdominal aorta (1) which supplies the liver, gallbladder, spleen, pancreases and from lower third of oesophagus to upper half of duodenum (2). CT is one of the common site for anatomical variation and Uflacker has described eight types of these variations in his Atlas of vascular anatomy (3). The prevalence of anatomical variations in CT has been reported ranging 9.4-39.3% by cadaveric and radiologic studies (1, 4).

Accurate knowledge and preoperative identification of celiac trunk variation is crucial for both surgeons and radiologists, before planning any upper abdominal operation and intervention (5, 6). This may enable surgeons and interventional radiologists to avoid unintentional vascular damages and complication (7). Recent advancement in imaging provides opportunities for researchers to review vascular variations and compare them to the previous classical anatomic studies and highlight their clinical importance.

Multi detector computed tomographic angiography is a non-invasive evaluation of normal and variable vessels which reconstract high quality 3D reconstructed images (5).

The introduction of five new types of CT variations not mentioned in the Uflacker's classification was uniqueness for this study. They are celiac-phrenic trunk and association of IPA with other Uflacker's variant types, Buhler arc, accessory hepatic artery from the CT and the association of celiac-colic trunk with gastro-splenic and hepato-splenic trunk in two cases each.

2. Materials and methods

The ethics committee approved this retrospective cross-sectional study. A total of 140 patients were selected, 23 were excluded, and 117 patients were included in the study. The patients underwent CTA (abdomen) for any reason, including those who underwent arterial phase computed tomography for the liver and renal protocol at Hospital Tengku Ampuan Afzan (HTAA) Kuantan Malaysia from June 2017 to March 2018.

Images were acquired with a 256-slice Siemens CT SOMATOM Definition Flash (Siemens, Erlangen, Germany). The contrast agent used is an ionic contrast agent, Iopamidol 300mgI/ml, total volume 120ml. A dual main injector was used to administer the contrast medium, which

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Received 14 Nov 2024; Received in revised form 19 Nov 2024; Accepted 28 Nov 2024; published Online 04 Dec 2024.

allows simultaneous injection of a compact bolus of iodine followed by a bolus of normal saline, both at the same injection rate of 4.5–5.0 mL/s.

Images were acquired from a picture archiving and communication system (PACS) and transferred to Syngo via workstation for image review. Multiplan reconstruction (MPR) in three spatial planes and three-dimensional (3D) reconstructions using maximum intensity projection (MIP) and volume rendering technique (VRT) were performed.

Inclusion criteria

All patients who underwent CT angiography of the abdominal aorta and its branches and computed tomography arterial phase performed for CT liver and renal protocol, for various reasons in HTAA, from June 2017 to March 2018.

Exclusion criteria

- Images corrupted by motion or metallic objects.
- Images from patients with tumor or aneurism that are totally incomprehensible or significantly misleading vascular anatomy.

The origin of CT trunk and its principle branches including left gastric artery (LGA), common hepatic artery (CHA) and splenic artery (SP) were identified and recorded for statistical analysis. Anatomical variations of CT were described according to Uflacker's classification (3).

Statistical Analysis

The prevalence of normal and variant anatomy of the celiac trunk was measured by calculation of frequencies and percentages using Chi-square test in IBM SPSS statistics version 22. A significance level of less than 5% ($P<0.05$) was measured statistically significant.

3. Results

A total of 117 patients were involved in this study, of which 77 (65.8%) were men and 40 (34.2%) were women. The mean (SD) age was 58 (14.4) years, with a minimum age of 24 years and a maximum age of 82 years.

The prevalence of normal celiac trunk trifurcation formed by the LGA, the CHA, and SP (Uflacker's type I) was found in 63 (53.8%) of cases of which 16 (25.5%) cases showed classic trifurcation where CHA, LGA and SA had a common point of origin and 47 (74.5%) cases were found non classical trifurcation, where the origin of LGA was variable along the celiac axis between its origin from the aorta and the point where it bifurcates into CHA and SP as depicted in (Table 1).

Table 1. Celiac trunk variations

Type of variation	Uflacker's types	Number of cases	Percentage (%)	Cumulative Percentage (%)
Trifurcation	I	63	53.8	53.8
Hepato-splenic trunk	II	5	4.3	58.1
Gastro-splenic trunk	V	2	1.7	59.8
Celiac-mesenteric trunk	VI	1	.9	60.7
Celiac-colic trunk	VII	15	12.8	73.5
Celiac-phrenic	N/A	21	17.9	91.5
Buhler Arc	N/A	2	1.7	93.2
Accessory hepatic artery	N/A	4	3.4	96.6
GS + CC	V + VII	2	1.7	98.3
HS + CC	II + VII	2	1.7	100.0
Total		117	100.0	

On the other hands, the variations of CT was found in 54 (46.2%) of the cases. However these variability were reported by Uflacker's classification in 86 (73.5%) cases, while 31 (26.5%) cases exhibited variations not included in Uflacker's classification. One of the most common variation in our study was IPA (left/right or both) arising from the CT which was counted for 21 (17.9%) of cases tracked by the celiac-colic trunk (Uflacker's type VII) in 15 (12.8%) cases as shown in (Figure 1).

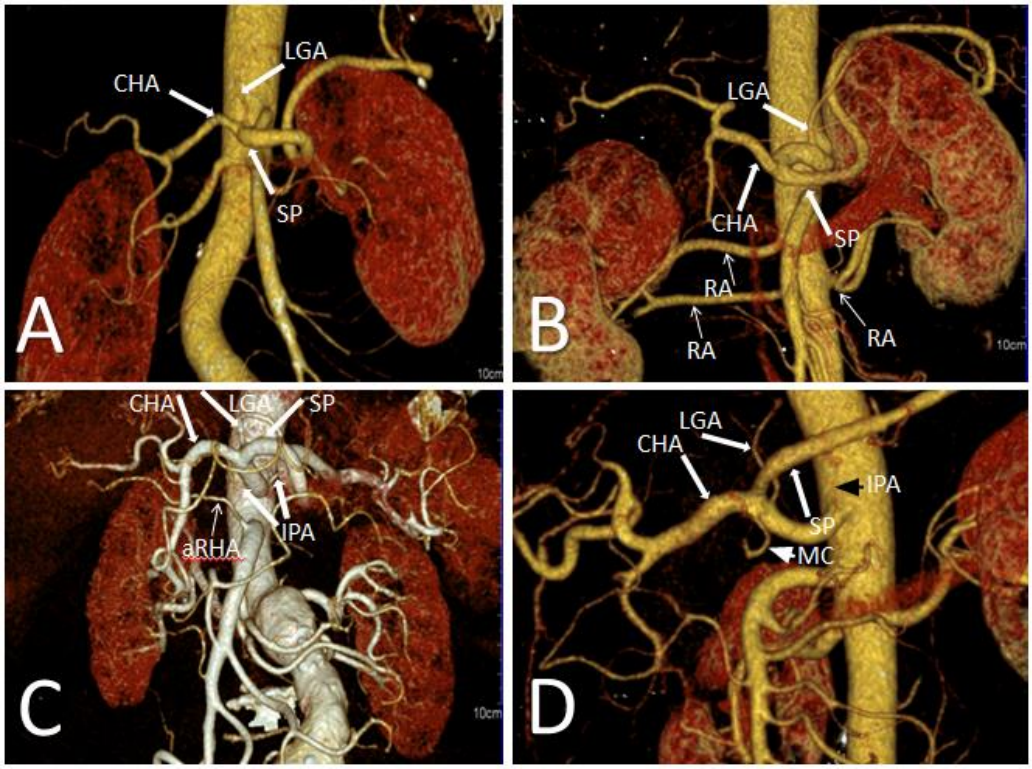

Figure.1. 3D VR images (A and B) show normal trifurcation of the CT into CHA, LGA and SP (Uflacker's type Ⅰ). (A) Classic trifurcation. (B) Non-classic trifurcation where the LGA originates from the CT and then it bifurcates into CHA and SP. Notice the double renal arteries. (C and D) show pentafurcation of the CT. (C) Show both IPA arise from the CT. Notice the accessory right hepatic artery from the SMA. (D) Depicts left IPA and middle colic arteries originate for the celiac trunk.CHA (Common hepatic artery), LGA (Left gastric artery), SP (Splenic artery), RA (Renal artery), IPA (Inferior phrenic artery), aRHA (accessory right hepatic artery), MD (Mid colic artery).

Hepato-splenic trunk (Uflacker's type II) was detected in 5 (4.3%) cases, accessory hepatic artery originated directly from the celiac trunk in 4 (3.4%) cases, and Gastro-splenic trunk (Uflacker's type V), coexistence of celiac-colic with gastro-splenic trunk, hepato-splenic trunks and Buhler arc were detected in 2 (1.7%) cases each. The least common variation was celiac-mesenteric trunk (Uflacker's type VI) was found only in one (0.9%) case as shown in (Figure 2). Uflacker's type III, IV and VIII were not detected in our study population.

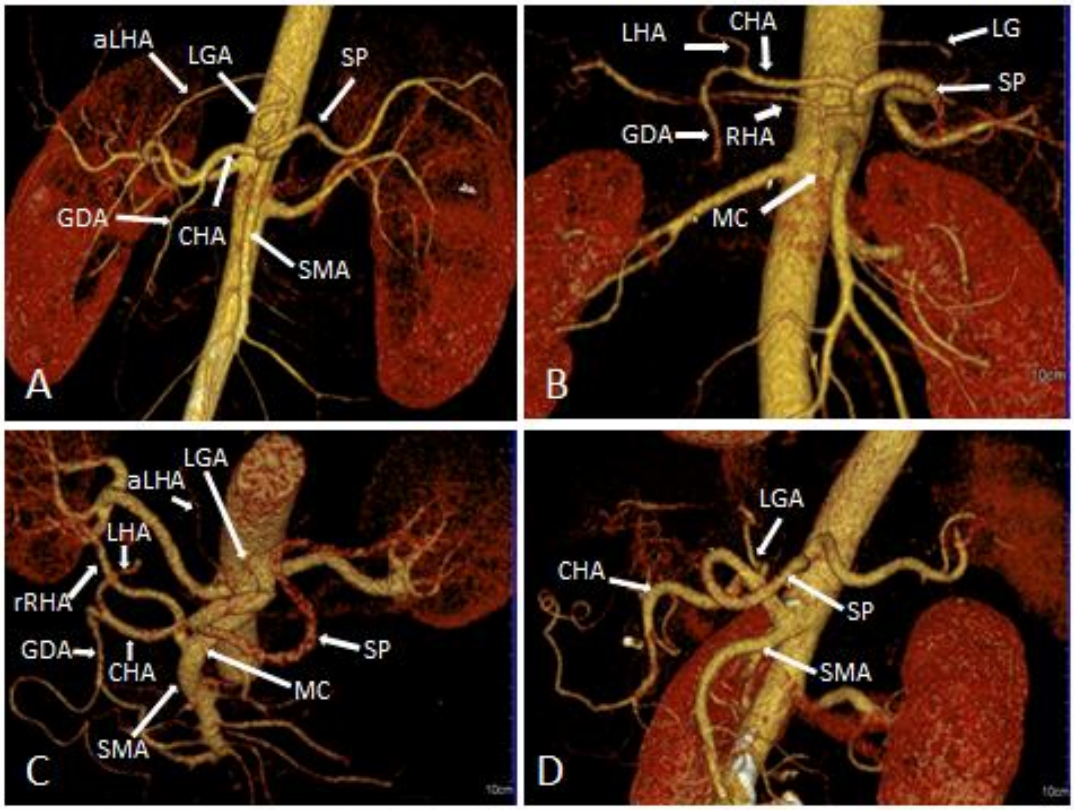

Figure 2. 3D VR images (A) Bifurcation of the CT shows the hepato-splenic trunk (Uflackers's type Ⅱ), LGA arises directly from the aorta. (B) CT has four branches CHA, LGA, SP and RHA which originates directly from CT as a fourth branch and then MC originated from RHA. (C) CT shows coexistence of Hepato-splenic and Celiac-colic trunks (Uflackers's type Ⅱ + Ⅶ), LGA originates directly from the aorta and gives off an accessory LHA, notice the replaced RHA arises from the SMA. (D) Celiac-mesenteric trunk (Uflacker's type Ⅵ) where the celiac trunk and SMA have a common point of origin.

CHA (Common hepatic artery), LGA (Left gastric artery), SP (Splenic artery), RA (Renal artery), IPA (Inferior phrenic artery), aRHA (accessory right hepatic artery), aLHA (accessory left hepatic artery), GDA (Gastro duodenal artery), SMA (Superior mesenteric artery), rRHA (replaced right hepatic artery), MD (Mid colic artery).

When the number of CT branches were observed it was found that the majority of cases 68 (58.1%) had 3 branches, followed by 4 branches in 39 (33.3%) cases as shown in (Table 2). In addition, there were 5 branches in 5 (4.3%) cases, 2 branches in 4 (2.4%) cases and only one case (0.9 %) was found with 6 branches.

Table 2. The numbers of celiac trunk branches

Number of branches	Number of cases	Percentage (%)	Cumulative Percentage (%)
Bifurcation	4	3.4	3.4
Trifurcation	68	58.1	61.5
Quadrifurcation	39	33.3	94.9
Pentafurcation	5	4.3	99.1
Hexafurcation	1	.9	100.0
Total	117	100.0	

Another interesting bifurcation of CT was also observed as hepato-splenic trunk (Uflacker's type II), where the LGA was originated from the SP artery. The right gastric artery was originated from the proper hepatic artery with a tortuous course and then it was giving off accessory LHA as shown in (Figure 3). To best of our knowledge, this type of variation has never been reported in the literature

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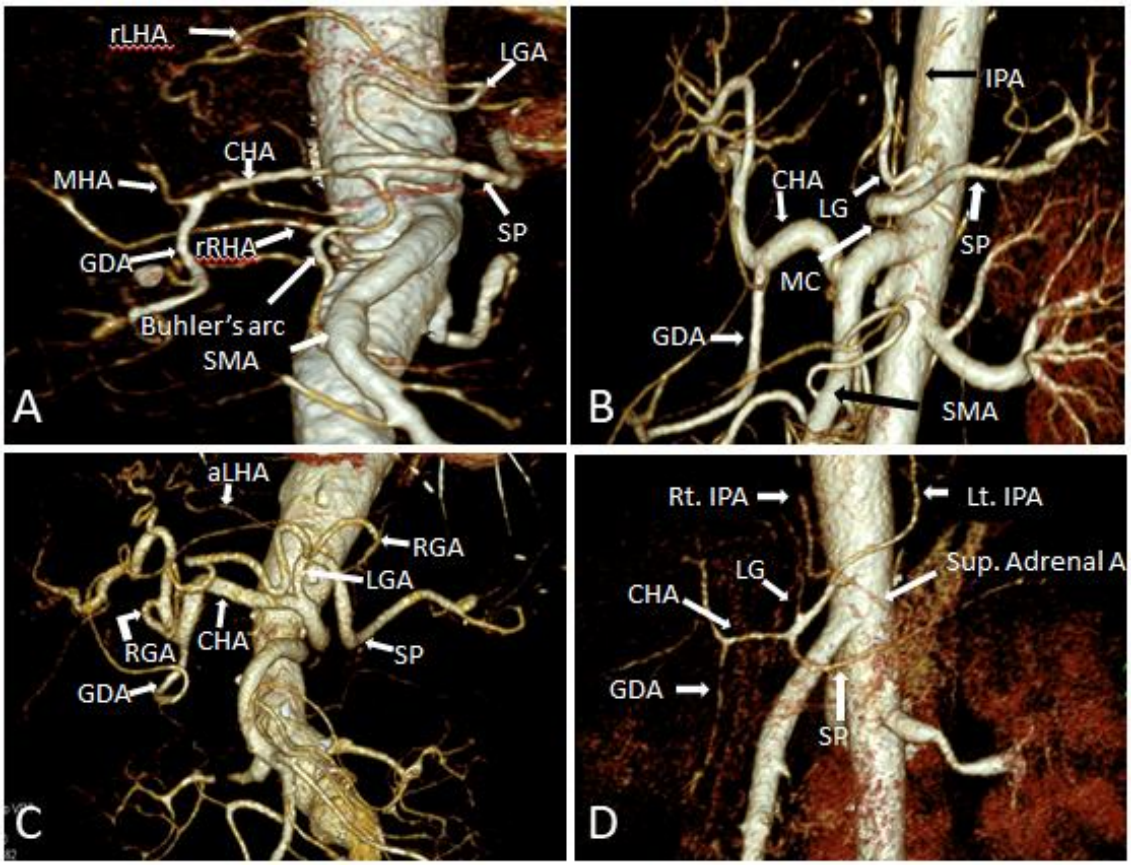

Figure 3. 3D VR images (A) Shows Buhler's arch which connects the CT with the SMA and represent qurdrifurcation of the CT.where the rLHA arises from the LGA and rRHA arises from SMA and the MHA is a branch of CHA. (B) Bifurcation of CT as gastro-splenic trunk where the IPA as a variant brache of the CT. CHA originates from SMA as hepato-mesenteric trunk. (C) Shows Hepato-splenic trunk (Uflacker's type Ⅱ), where the LGA is originated from the SP artery. The RGA arises from the proper hepatic artery and gives off aLHA. (D) Shows Hexafurcation of the CT with normal trifurcation along with another trifurcation where both IPA and left superior adrenal artery originate with a common trunk from the celiac trunk.

CHA (Common hepatic artery), MHA (Main hepatic artery), rLHA (Replaced left hepatic artery), rRHA (Replaced right hepatic artery), LGA (Left gastric artery), SP (Splenic artery), IPA (Inferior phrenic artery), GDA (Gastro duodenal artery), MD (Mid colic artery), SMA (Superior mesenteric artery), aLHA (accessory left hepatic artery), RGA (Right gastric artery), LGA (Left gastric artery).

4. Discussion

The mean age in our study was 58 years, which shows parallel results with other studies. This is because most people in this age suffer from high blood pressure, aortic aneurysms, chronic liver diseases, kidney problems and go to health centres and for treatment (8).

CT is the first ventral branch of the abdominal aorta, which arise immediately below the aortic opening of diaphragm between the lower border of the 12th thoracic and the upper border of the first lumber vertebra. Its length is 1.5-2 cm. It is divided into three branches, the left gastric, common hepatic and splenic arteries (2, 9).

In Uflacker's classification, the main variants of CT are classified into 8 types where the most common variation regarded as normal trifurcation (Uflacker's type I). Other types including II-VIII are described as Hepato-splenic trunk, Hepato-gastric trunk, Hepato-spleno-mesenteric trunk, Gastro-splenic trunk, Celiac-mesenteric trunk, Celiac-colic trunk and the absent CT respectively (3).

The prevalence of normal trifurcation of the CT in our study was found in 63 (53.8%) of cases which is the most common variation and it has also been reported by the previous studies (1, 10-12). Variations in celiac trunk in our study was found 54 (46.2%) cases which show two times higher than reported in other studies ranging 10-28%. However, Ferrari et al has reported 56.6% of normal trifurcation of CT which is very close to our findings (13). Olewnik et al and Zagyapan et al have found that the normal trifurcation of CT was counted for 62.5% of cases (10, 14), Iezzi et al reported 72.1% of normal trifurcation (15) Adachi, Araujo Neto et al, and Selvaraj have found the normal trifurcation of CT in 86%, 90% and 90.6% of cases respectively (1, 4, 10).

Based on the number of branches, the most common pattern of celiac trunk in our finding was trifurcation 68 (58.10%) followed by quadrifurcation in 39 (33.3%). Mburu et al reported 61.7% of cases with trifurcation which is consistent with our finding (16).

The most common variation in our study was the origin of inferior phrenic arteries (IPAs) from celiac trunk which was counted for 21 (17.9%) of cases. Pushpalatha and Olewnik et al have also reported this variation as the most common variation with 14% and 12% respectively (10, 17).

The IPAs usually arise from both sides of abdominal aorta just beneath the aortic opening of diaphragm and supply the diaphragm inferiorly. Sometimes, they may also arise from the CT separately or with a common point of origin (18). Surgeons must take care of this type of variation of small arteries during CT handling to avoid iatrogenic bleeding. Recently, with the involvement of IPAs in the arterial supply and growth of hepatocellular carcinoma, these arteries have expected more attention (19).

The second common variation was the celiac-colic trunk 15 (12.8%) case, followed by Hepato-splenic trunk 7 (6.1%) cases. This variation is revealed in other studies 8-15% of all cases (10). Gastro-splenic trunk in our study was found in 4 (3.4%) cases. This variation was reported by Arifuzzaman et al as the second most common variation which was counted for 8.2% of cases(20). Accessory hepatic artery in 4 (3.4%) cases and only one case of celiaco-mesentric trunk (0.9%), which is consistent with Rountas quoted report of a review article by Yi et al, which reported 1.5% of this variation (21).

We found a rare variation of Buhler arch in 2 cases. Buhler arch is a branch which connects both celiac trunk and SMA.

One limitation of the higher prevalence of this variation might be because of the relatively small number of populations studied compared to other studies, however this was the first study in a Malaysian population and different prevalence rates were reported in different countries (16). Furthermore, MDCTA has a higher sensitivity than dissection, where small branches such as IPAs are difficult to preserve during dissection.

5. Conclusion

Anatomical variations in CT could be found in one out of each two to three patients undergoing any invasive imaging or procedure. Accurate knowledge about these variations enables surgeons and interventional radiologists to prevent or minimize unintentional vascular damages and accomplish safe operation and intervention.

Ethical considerations

International Islamic University of Malaysia (IIUM) Research Ethical Committee (IREC) approved this study and National Medical Research Registration was obtained in advance to conducting the study

Acknowledgements: It is worth to be mentioned that all authors appreciate and thank from the head and all staff in department of diagnostic imaging HTAA and departments of basic medical science and radiology IIUM for their valued assistance and cooperation.

Conflict of interest: It is declared by the authors that there were no conflict of interest related to the subject matter of this study.

Authors Contributions: Conceptualization, methodology, software, analysis, investigation, resources, original draft preparation, review and editing, visualization, supervision, project administration and funding acquisition. All authors have read and agreed to the published version of the manuscript.

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