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Mini review

Variations in the anatomy of the celiac trunk: A systematic review and clinical implications

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ABSTRACT

The normal pattern of the celiac trunk (CT) implies its bifurcation to three branches, the common hepatic, the splenic and the left gastric artery. According to the available literature the CT presents several anatomical variations. The purpose of our study is to investigate the different types of these variations, the corresponding incidences and the probable influence of genetic factors, as they are presented in the existing literature. Four databases were searched for eligible articles for the period up to January 2013 and a total of 36 studies were collected. The CT was trifurcated into the three basic branches in the 89.42% (10,906/12,196) of the cases. Bifurcation of the CT occurred in the 7.40% of the pooled samples (903/12,196). Absence of the CT was the rarest variation with a percentage of 0.38% (46/12,196), hepatosplenomesenteric trunk was found in 49 out of the 12,196 cases (0.40%) and the celiacomesenteric trunk presented an incidence of 0.76% (93/12,196). Other variations of the CT were detected in the 1.64% of the pooled cases (199/12,196). The 14.9% of the cases in the cadaveric series (489/3278 specimens), the 10.5% in the imaging series (675/6501 specimens) and the 4.6% (104/2261) in the liver transplantation series presented variations. These differences are statistically significant ($p < 0.001$). The Japanese and Korean populations presented more variations in the CT than Caucasians ($p < 0.05$ and $p < 0.001$). Negro, colored and black populations presented more variations of the CT than Indian ones ($p > 0.05$).

Using those data, a novel classification of CT variations is proposed.

1. Introduction

The celiac artery or (more commonly referred as) celiac trunk (CT), constitutes a surgically significant splanchnic branch of the abdominal aorta and thus it has been studied thoroughly. Knowledge of the variable anatomy of the CT is clinically important in the treatment of abdominal aortic aneurysms, in liver, pancreatic and oesophagogastric surgery, in organ retrievals and in liver transplantations.

The normal pattern of the CT seems to be the so called "*tripus Halleri*", namely its bifurcation to three branches, the common hepatic, the splenic and the left gastric artery. Higashi et al. (2009) introduced a classification of the possible forms of the *tripus Halleri* in four types: In Type I the CT ended divided into two branches (splenic and common hepatic arteries), while the left gastric artery emerged earlier along the trunk. In Type II the three arteries had a common origin while in the two other types the first branch was the common hepatic artery and the splenic artery respectively (Table 1). A detailed description of these forms has been made in a previous paper (Venieratos et al., 2012).

Beyond the anomalies reported on the normal pattern (Lipshutz, 1917; Petrella et al., 2007; Iezzi et al., 2008; Higashi et al., 2009; Mburu et al., 2010), the CT presents several anatomical variations such as the absence of one of its branches (bifurcation or incomplete CT), additional branches, common origin with the superior mesenteric artery (celiacomesenteric trunk), common origin with the superior and inferior mesenteric artery (celiac-bimesenteric trunk) and total absence. There are several reports and studies in the available literature describing and analysing the different forms of the CT individually or in a sample of population, while there have been numerous efforts of classification of its ramification types (Lipshutz in 1917; Adachi in 1928; Morita in 1935; Michels in 1955, Table 1). Since each author proposes a classification of his own findings, it is natural that none of them includes all variations observed up to the present.

The statistical significance of the discrepancies among the different studies on the frequency of the anatomical variations of the CT is not widely known and it is controversial whether their presence is dependent on ethnic and gender factors. On the other hand the existence of diverse nomenclatures may be confusing and misleading.

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Consequently, the need for an up-to-date systematic review is evident. Our study has been designed to take into account the reports in the literature so far, in order to investigate:

1. The different types of anatomical variations of the CT and the correspondent incidences.
2. The overall probability of occurrence of any variation type in an extensive sample.
3. The probable influence of factors such as gender, race and the type of study.

Additionally, based on the accrued results, an effort has been made to establish a more comprehensive and easily used classification.

2. Materials and methods

Four databases were searched for eligible articles for the period up to January 2013 (MEDLINE, SCOPUS, ISI web of knowledge, and PUBMED). No publication year restrictions were imposed. The following terms and combination of them were used: "celiac artery", "celiac trunk", "coeliac", and "celiac". The references of all the articles which were considered relevant were checked to find any studies missed. Additionally, five anatomical textbooks (Adachi, Michels, Lippert and Pabst, Gray's Anatomy, and Bergman) were looked through for any kind of documentation concerning the CT.

The following criteria for inclusion of data in the study were used:

1) The study must be an original research article or a review examining the anatomical variations of the CT in a population sample (cadaveric or clinical study). Studies which were conducted during liver transplantations and provided detailed data about the variations of the CT were also included. Single case reports and studies with populations overlapping with other ones were excluded.
2) Only studies concerning adult humans were selected.
3) There were no limitations imposed concerning race, age, sex, journal, language or publication year. No efforts were made to search unpublished material.

For each study considered eligible the following parameters were investigated: year of publication, type of the study (cadaveric, clinical, imaging), demographic characteristics of the population being studied (gender and race), frequencies and classification of the reported variations.

The collected data were categorized according to the provisional groups below mentioned in order to render the various data as comparable as possible and to avoid confusion arising from differences in nomenclature:

Group 1: Every celiac artery giving rise to the three normal branches (common hepatic, left gastric and splenic artery), regardless of presence of a common origin (true tripod –"*tripus Halleri*") or one of them emerging first (false tripod; Type I of Lipshutz's; Adachi's, Morita's and Michel's classification; all types of Higashi classification, Table 1) was classified as complete or trifurcated CT (Fig. 1). This type constitutes the classical pattern of the CT. The rest of the groups correspond to variations of the artery.

Group 2: The incomplete or bifurcated CT group included every celiac artery which had only two of the three normal branches, the third being a branch of another artery (Types II, III and IV of Lipshutz's classification; Types II, V and VI of Adachi's classification; Types II, III and IV of Morita's classification; Types II, IV and V of Michel's classification and every other form of bifurcation, Table 1). The different types of bifurcation were also studied individually, when there was data available.

Table 1
Classifications of the celiac trunk (CT).*

Higashi's classification of the celiac tripod (hepatosplenogasrtic trunk)	
Type I	the left gastric artery was the first branch
Type II	the three main arteries branched out at the same vertebral level.
Type III	the common hepatic artery was the first branch
Type IV	the splenic artery was the first branch
Lipshutz's classification of the celiac trunk (CT)	
Type I	trifurcation of the CT *(tripus Halleri)*
Type II	hepatosplenic trunk, LGA arising from the AA
Type III	hepatogastric trunk, SA arising from the AA
Type IV	splenogastric trunk, CHA arising from the AA
Adachi's classification of the celiac trunk (CT)	
Type I	trifurcation of the CT *(tripus Halleri)*
Type II	hepatosplenic trunk, LGA arising from the AA
Type III	hepatosplenomesenteric trunk, LGA arising from the AA
Type IV	celiacomesenteric trunk
Type V	gastrosplenic trunk and hepatomesenteric trunk
Type VI	gastrosplenic trunk, CHA arising from the SMA
Morita's classification of the celiac trunk (CT)	
Type I	trifurcation of the CT *(tripus Halleri)*
Type II	hepatosplenic trunk, LGA arising from the AA
Type III	splenogastric trunk, CHA arising from the AA
Type IV	hepatogastric trunk, SA arising from the AA
Type V	absence of the celiac trunk
Michel's classification of the celiac trunk (CT)	
Type I	trifurcation of the CT *(tripus Halleri)*
Type II	hepatosplenic trunk, LGA arising from the AA, SA or CHA
Type III	hepatosplenomesenteric trunk, LGA arising from the AA
Type IV	hepatogastric trunk, SA arising from the SMA
Type V	splenogastric trunk, CHA arising from the SMA *(or other structures)*
Type VI	celiacomesenteric trunk

* LGA, left gastric artery; AA, abdominal aorta; SA, splenic artery; CHA, common hepatic artery; SMA, superior mesenteric artery.

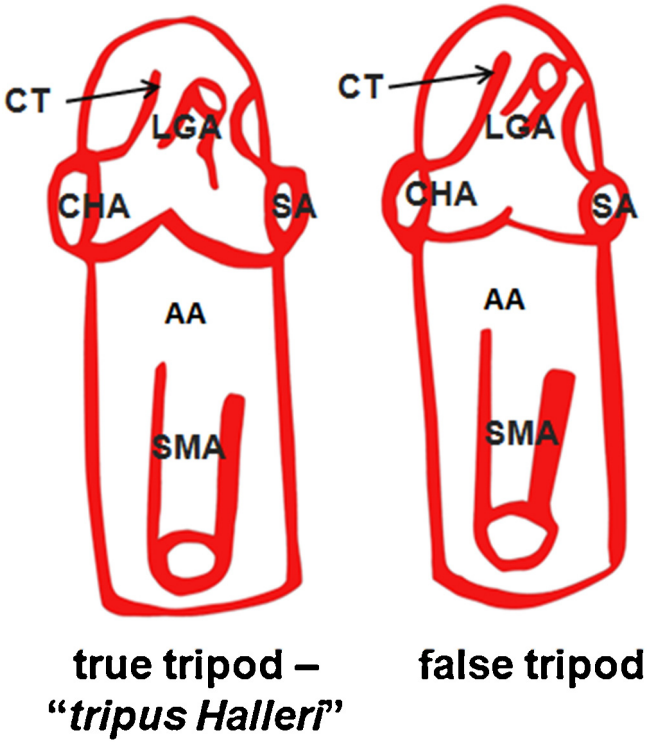

Fig. 1. Complete or trifurcated celiac trunk (CT) (Group 1). True tripod: common hepatic (1), splenic (2), and left gastric artery (3), have a common origin. False tripod: one of the three branches emerge first (here the left gastric artery (3)). SMA, superior mesenteric artery, AA, abdominal aorta.