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CASE REPORT

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# An anomalous origin of the gastrosplenic trunk and common hepatic artery arising independently from the abdominal aorta: a case report using MDCT angiography

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## Abstract

The authors describe a case of a 61-year-old female patient, which presented on multidetector computed tomographic (MDCT) angiography a gastrosplenic trunk (GST) and common hepatic artery (CHA) arose independently from abdominal aorta (AA). The GST arose from the anterior wall of the AA, at the level of upper edge of the L1 vertebral body. The left gastric artery (LGA) arose from the superior wall of the GST. The splenic artery (SA) continuous the path of GST. The CHA arose from the anterior wall of the AA, at the level of upper one third of the L1 vertebral body, at 15.3 mm above the origin of superior mesenteric artery (SMA). The incidence and developmental and clinical significance of this vascular variation is discussed with a detailed review of the literature.

***Keywords***: gastrosplenic trunk, common hepatic artery, anatomic variants, multidetector computed tomographic angiography.

## Introduction

The normal anatomical appearance of the celiac trunk (CT) with forking in three branches: left gastric artery (LGA), common hepatic artery (CHA), and splenic artery (SA), described by Haller, in 1756, is considered to be the normal anatomical appearance [1–5]. This condition was highlighted in the literature between 72.29% [6] and 90.78% [7].

In 1928, the anatomic variations of the CT were classified by Adachi [8] into six types (with 28 forms). Based on Tandler's embryological hypothesis [9], Morita [10] classified the variation patterns of the CT in five types and celiacomesenteric trunk (CMT) in four types and 10 forms (Table 1).

Morita's classification did not consider the positional relationship between the portal hepatic vein and the hepatic artery [11]. Because of this, the type V [gastrosplenic trunk (GST) and hepatomesenteric trunk (HMT)] and type VI [GST and accessory right hepatic artery from superior mesenteric artery (SMA)] of Adachi's classification are included in the type IV' (GST and HMT) of Morita's classification. Following 24 studies in the literature, Lippert & Pabst [12] highlight the presence of GST in 3% of cases, situation in which the CHA is absent or an independent branch of the abdominal aorta (AA). On a large series of cases {6774 cases from eight studies [6–8, 11, 13–16] (Table 2)}, the GST [(*i*) in association with HMT, (*ii*) in association with accessory right hepatic artery from SMA, and (*iii*) in association with CHA arising independently from AA] was revealed in 3.08% of cases. Isolated cases of GST in association with HMT were highlighted on anatomical dissection [17–19]. New generations of multidetector computed tomographic (MDCT) angiography have improved the quality of imaging due to high spatial resolution, shortened scan time, and enlarged coverage [2, 20–22].

**Table 1 –** ***Correlations of the Adachi and Morita classifications***

| Adachi's classification (1928) [8] | | Morita's classification (1935) [10] | |
|---|---|---|---|
| ***Celiac and superior mesenteric trunks*** | ***Types*** | ***Celiac trunks*** | ***Types*** |
| Hepatogastrosplenic | I | Hepatogastrosplenic | I |
| Hepatosplenic | II | Hepatosplenic | II |
| | | Gastrosplenic | III |
| | | Hepatogastric | IV |
| | | Absent CT | V |
| | | ***Celiacomesenteric trunks*** | ***Types*** |
| Celiacomesenteric | IV | Celiacomesenteric | I' |
| Hepatosplenomestenteric | III | Hepatosplenomesenteric | II' |
| | | Hepatogastromesenteric | II'' |
| | | Gastrosplenomesenteric | II''' |
| | | Hepatomesenteric | III' |
| | | Gastromesenteric | III'' |
| | | Splenomesenteric | III''' |
| Gastrosplenic & Hepatomesenteric | V | Gastrosplenic & Hepatomesenteric | IV' |
| Gastrosplenic & Accessory right hepatic artery from SMA | VI | | |
| | | Hepatosplenic & Gastromesenteric | IV'' |
| | | Hepatogastric & Splenomesenteric | IV''' |

CT: Celiac trunk; SMA: Superior mesenteric artery.

**Table 2 –** ***Incidence of presence of the gastrosplenic trunk reported in large series using different methodologies***

| **Author** | **Lipshutz [6]** | **Eaton [7]** | **Adachi [8]** | **Michels [13]** | **Chen *et al.* [11]** | **Song *et al.* [14]** | **Ugurel *et al.* [15]** | **Venieratos *et al.* [16]** | **Total** | **AD** | **RP** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Year | 1917 | 1917 | 1928 | 1942 | 2009 | 2010 | 2010 | 2012 | | | |
| Method of examination | AD | AD | AD | AD | AD | RP | RP | AD | | | |
| No. of subjects (percent) | *n* (%) | *n* (%) | *n* (%) | *n* (%) | *n* (%) | *n* (%) | *n* (%) | *n* (%) | *n* (%) | *n* (%) | *n* (%) |
| Hepatogastrosplenic trunk (CT) | 61 (73.49) | 187 (90.78) | **T I** 221 (87.7) | 45 (90) | 875 (89.84) | 4457 (89.1) | 89 (89) | 57 (74) | 5992 (88.85) | 1.446 (88.06) | 4546 (89.1) |
| Hepatosplenic trunk | 11 (13.25) | 9 (4.37) | **T II** 6 (6.35) | 2 (4) | 43 (4.41) | 221 (4.42) | 3 (3) | 13 (16.9) | 318 (4.72) | 94 (5.72) | 224 (4.39) |
| Hepatosplenomestenteric trunk | | | **T III** 3 (1.19) | | 7 (0.72) | 34 (0.68) | 1 (1) | | 45 (0.67) | 10 (0.61) | 35 (0.69) |
| Celiacomesenteric trunk | 2 (2.41) | | **T IV** 6 (2.38) | | 7 (0.72) | 53 (1.06) | | | 68 (1.01) | 15 (0.91) | 53 (1.04) |
| Gastrosplenic & Hepatomesenteric trunks | | 9 (4.37) | **T V** 1 (0.4) | | 34 (3.49) | 132 (2.64) | | | 176 (2.61) | 44 (2.68) | 132 (2.59) |
| Gastrosplenic trunk & Accessory right hepatic artery from SMA | | | **T VI** 5 (1.98) | 2 (4) | | | | | 7 (0.1) | 7 (0.43) | |
| Gastrosplenic trunk & Common hepatic artery from abdominal aorta | 3 (3.62) | 1 (0.48) | | | 5 (0.51) | 11 (0.22) | 4 (4) | 1 (1.3) | 25 (0.37) | 10 (0.61) | 15 (0.29) |
| Others | 6 (7.23) | | | 1 (2) | 3 (0.31) | 94 (1.88) | 3 (3) | 6 (7.8) | 113 (1.67) | 16 (0.98) | 97 (1.9) |
| **Total** | **83 (100)** | **206 (100)** | **252 (100)** | **50 (100)** | **974 (100)** | **5002 (100)** | **100 (100)** | **77 (100)** | **6744 (100)** | **1642 (100)** | **5102 (100)** |

AD: Anatomical dissection; CT: Celiac trunk; RP: Radioimagistic procedures; SMA: Superior mesenteric artery.

We present a very rare case of GST in association with CHA arising independently from AA highlighted incidentally by MDCT angiography. The incidence, developmental and clinical significance of it is discussed with a brief review of the literature.

## Case presentation

We report the case of a 61-year-old female with a 15-year history of peripheral vascular disease of the lower limbs. Using MDCT angiography (64-slice MDCT system; SOMATOM Sensation, Siemens Medical Solutions, Forchheim, Germany), the patient was shown to have, in association with the vascular lesions of the lower limbs, the presence of a GST, the CHA and SMA arose independently from the AA, and one additional right renal artery (Figure 1). The GST with an endoluminal diameter of 7 mm at its origin and a length of 13.6 mm arose from the anterior wall of the AA at the left of the mediosagittal plan at the level of upper edge of the L1 vertebral body, 20 mm above the origin of the SMA. The LGA, with an endoluminal diameter of 3.7 mm at its origin, arose from the superior wall of the GST and it ran upwards in front of the antero-lateral left face of AA, and after 28.6 mm gave rise to esophageal branches. The SA, with an endoluminal diameter of 7 mm at its origin, continuous the path of GST to the left and slightly higher, for splenic hilum with less tortuous trajectory (with a splenic artery index of 1.23). The CHA, with an endoluminal diameter of 8 mm at its origin, arose from the anterior wall of the AA at the level of upper one third of the L1 vertebral body, 15.3 mm above the origin of the SMA. It ran horizontally, to the antero-lateral right, and after a trajectory of 66 mm it forked into the hepatic artery proper (HAP) and gastroduodenal artery (GDA). The GDA have an endoluminal diameter of 2.1 mm at its origin. The HAP ran upwards supero-lateral right and after a trajectory of 37.6 mm, it forked into the medial and lateral branch. To 21.2 mm from the origin of AA, the trunk CHA give rise to the replaced right hepatic artery that after passing between the inferior vena cava and hepatic portal vein splits in anterior and posterior branches. The SMA with an endoluminal diameter at origin of 8 mm arose directly from the anterior wall of the AA at the level of middle one third of L1 vertebral body. The main renal arteries arose from the right and left wall of the AA, at the level of L1–L2 intervertebral disk. The additional right renal artery arose from the right edge of AA at the level of lower one third of L1 vertebral body.

### Consent

Written informed consent was obtained from the patient for the X-ray examination and the use of iodinated contrast agents in accordance with an investigation protocol. Also, a written informed consent was obtained from the patient for publication of this case report and accompanying images. In this manuscript, no data were revealed regarding the patient identity.

## Discussions

### Classification

Based on Tandler's hypothesis [9], Morita [10] classified the variational patterns of CT and SMA, and suggested five types and 15 forms. For CT, Morita [10] describes five types: (I) hepatogastrosplenic trunk (CT), (II) hepatosplenic trunk in association with independent arising of LGA; (III) GST in association with independent arising of CHA; (IV) hepatogastric trunk in association with independent arising of SA; (V) absent CT, with independent arising of CHA, LGA and SA. For CMT, Morita [10] describes four types with 10 forms; type IV' is represented by the association of GST with HMT. Morita's classification [10] describes for the first time the HMT in association with independent arising of LGA and SA.

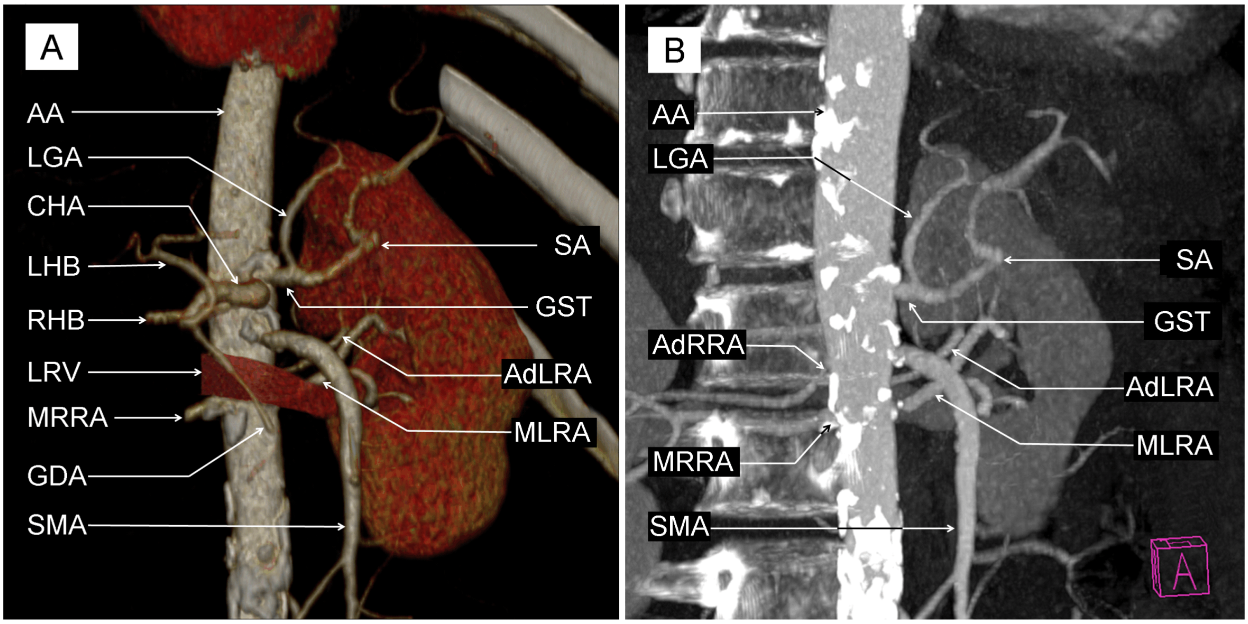


**Figure 1 –** ***MDCT angiography of the abdominal aorta from anterior aspect. The volume rendering technique (VRT) (A) and the maximum intensity projections (MIP) (B) images show the abdominal aorta with the origin of the gastrosplenic trunk, common hepatic artery, superior mesenteric artery, renal and additional renal arteries. MDCT: Multidetector computed tomography; AA: Abdominal aorta; LGA: Left gastric artery; CHA: Common hepatic artery; LHB: Left hepatic branch; RHB: Right hepatic branch; LRV: Left renal vein; MRRA: Main right renal artery; GDA: Gastroduodenal artery; SMA: Superior mesenteric artery; SA: Splenic artery; GST: Gastrosplenic trunk; AdLRA: Additional left renal artery; MLRA: Main left renal artery; AdRRA: Additional right renal artery.***

Adachi [8] described six types (with 28 forms) of the branching pattern of CT and SMA. In this classification, type V is represented by the association of GST and HMT and type VI the GST in association with the right hepatic artery arising from SMA. Lippert & Pabst [12] classified the branching pattern of the CT in three types (with 11 forms): (I) complete CT, (II) incomplete CT, and (III) common origin of main branches of the CT and SMA. In the second type, the incomplete CT is included also the GST. Gielecki *et al.* [23], depending on the number of branches, described six types of branching pattern of CT and SMA. In the type II (bifurcation) is included the GST in association with the independent arising of CHA (2a), and in the type VI (others), the association of GST and HMT (6b). Uflacker [24] described eight types of CT branching pattern variations. The V type is represented by the GST in association with the independent arising of CHA.

A number of three types of association of GST is included in these classifications: (*i*) GST in association with HMT [7, 8, 11, 14]; (*ii*) GST in association with the right hepatic artery arising from SMA [8, 13]; (*iii*) GST in association with the independent arising of CHA [6, 7, 11, 14–16].

### Embryology

The anatomical variations of the CT, SMA and inferior mesenteric artery are due to developmental changes in the ventral segmental arteries [25]. The four primitive roots of the ventral segmental arteries become, from top to bottom, the LGA, SA, CHA and SMA, respectively. The $10^{th}$-to-$13^{th}$ ventral segmental arteries are united by “longitudinal anastomosis”. According to the extent of the resorption/retention of four ventral segmental roots and some parts of this longitudinal anastomosis, many anatomical variants of CT and SMA develop. In the present case, the longitudinal anastomoses persist between the $10^{th}$ and the $11^{th}$ ventral segmental arteries, and regressed between $11^{th}$ and $13^{th}$ ventral segmental arteries. The $11^{th}$ root of the ventral segmental artery regresses, and its distal part connects with the $10^{th}$ ventral segmental artery to form the GST. The regress of longitudinal anastomosis between the $11^{th}$ and the $13^{th}$, with the persistence of the third and fourth roots of ventral segmental arteries, leads to the appearance of CHA and SMA with independent arising from AA [10, 17, 18].

### Anatomical variations

Of 6744 cases of anatomic dissections and radio-imaging procedures from eight studies [6–8, 11, 13–16] revealed the presence of: complete CMT in 1.01% of cases, with a prevalence from 0% [7, 13, 15, 16] to 2.38% [8]; complete CT in 88.85% of cases, with a prevalence from 73.49% [6] to 90.78% [7]; incomplete CMT in 0.67% of cases, with a prevalence from 0% [6–8, 16] to 1.19% [8]; incomplete CT in 7.8% of cases, with a prevalence from 7% [15] to 16.87% [6]; others in 1.67% of cases, with a prevalence from 0% [7, 8] to 7.8% [16]. The GST was revealed in 3.08% of cases, in three association: (*a*) GST in association with HMT (Adachi type V) in 2.61% of cases, varying between 0% [6, 13, 15, 16] to 4.37% [7]; (*b*) GST in association with accessory right hepatic artery from SMA in 0.1% of cases, between 0% [6, 7, 11, 14–16] to 4% [13]; (*c*) GST in association with CHA arising independently from AA in 0.37% of cases, between 0% [8, 13] to 4% [15]. The third group of GST (namely c-GST in association with CHA arising independently from AA), which also includes our case, is the least common anatomical variant of GST [6, 7, 11, 14–16].

Analysis of six anatomical studies, on a number of 1642 cases [6–8, 11, 13, 16], highlighted 10 cases (0.61% of cases) of GST and CHA from AA, with a prevalence range from 0% [8, 13] to 3.62% [6]. On 5102 radio-imagistic procedures [14, 15], the presence of GST and CHA from AA was highlighted in 15 (0.29%) cases, with a prevalence range from 0.22% [14] to 4% [15] (Table 1). Although the numerical differences are not large, we found that the percentage order of sensitivity of the GST in association with independent origin of CHA from AA recognition was anatomical studies and radioimagistic procedures, with a prevalence of 0.61% and 0.29%, respectively.

Regarding the endoluminal diameter at the origin of the celiac trunk components, it has been pointed out that they decrease from SA, CHA to LGA [26]; the same aspect is also described in the absence of CT as a morphological entity and the separate origin of all three arteries of AA (endoluminal diameter of LGA 3.3 mm, CHA 6 mm, and SA 6.2 mm [2]). When the GST is associated with the hepatomesenteric trunk, Harada *et al.* [17] reveals the significant predominance of the hepato-mesenteric trunk diameter (9.5 mm at origin, with the 9.2 mm endoluminal diameter of SMA, and 5.2 mm of the CHA endoluminal diameter), compared to the endo-luminal diameter of the GST of 4.4 mm at origin, with 2.4 mm of LGA endoluminal diameter, and 4.2 mm of SA endoluminal diameter. Compared to these data, in our case, both the endoluminal diameter of the LGA (3.7 mm), the SA (7 mm) are much higher than those reported by Harada *et al.* [17], while the endoluminal diameters of the CHA and the superior mesenteric artery at origin are equal (8 mm). The major variability of the tortuosity of the SA path from its origin to the splenic hilum caused the insertion into the literature of the index of splenic artery tortuosity. Studies by Borley *et al.*, in 1995 [27], reveals an average of this index of 1.83±0.62. Without being able to demonstrate, the authors suggest a correlation between this index and the age of the studied specimens. The value of the splenic artery tortuosity index of 1.23 in our case at the age of 61 years old contradicts this assumption.

The present case is only the 26th reported GST in association with an independently arising CHA from the AA and 16th using MDCT angiography.

## Conclusions

Awareness of the variations in the CT branching pattern is important for anatomists, interventional radiologists, oncologists, vascular, and abdominal surgeons. This study presents a very rare case of an anomalous origin of the GST, and CHA arising independently from the AA. Identification of such a variant vessel should not be ignored before planning radioimagistic intervention or surgical procedures to prevent possible risks. The MDCT angiography shows high sensitivity in the diagnosis of abdominal vascular anatomical variations.

### Conflict of interests

The authors declare that they have no conflict of interests.

### Author contribution

Nicoleta Iacob and Agneta Maria Pusztai contributed equally to this work.

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