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# **Hepatomesenteric trunk, gastrosplenic trunk, coiled splenic and hepatic arteries, and a variant of Bühler's arc**

Short title: Hepatomesenteric trunk and arc of Bühler

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## **Abstract**

The celiac trunk is normally divided into the left gastric artery (LGA), splenic artery (SA), and common hepatic artery (CHA). The combination between these arteries and the superior mesenteric artery (SMA) generates various combinations. We report here such a rare anatomic variant, namely the hepatomesenteric trunk (HMT), combined with a gastrosplenic trunk (GST). The variant was identified using computed tomography angiograms of a 62-years-old woman. The GST emerged from the aorta within the aortic hiatus of the diaphragm, a previously unknown possibility. Further, an accessory left hepatic artery originated from the LGA. The phrenic arteries had independent aortic origins. The HMT divided into the CHA and the SMA posterior to the origin of the hepatic portal vein (PV), above the pancreas. The

CHA initially had a right course, towards the superior border of the PV, then it descended with a transpancreatic course posterior to the PV, reached its inferior/right border, and divided antero-inferiorly to the PV into the proper hepatic (PHA) and gastroduodenal arteries. The PHA continued on the anterior side of the PV, sending off the left and right hepatic arteries. The HMT and the GST were connected by a rudimentary variant of the arc of Bühler, unreported previously. Arterial variations in the celiac region are accurately distinguished on computed tomography angiograms. They should be evaluated by surgeons when different surgical procedures are evaluated.

**Key words: aorta, celiac trunk, superior mesenteric artery, computed tomography, hepatic artery**

## **INTRODUCTION**

The celiac trunk (CT) normally sends off the left gastric artery (LGA), splenic artery (SA) and common hepatic artery (CHA) [6,25].

The presence of aberrant hepatic arterial anatomy increases the surgical complexity and subsequently the potential risk of injury to the hepatic arterial supply during pancreaticobiliary procedures and duodenopancreatectomies [23]. The aortic common origin of the CHA and superior mesenteric artery (SMA) is by a hepatomesenteric trunk (HMT) [9,14,15,20,21]. This is a rare anatomic variation [20,23]. The HMT was encountered in 0.5% [1], 2% [5], 2.08% [14], and in 4.47% [32]. Just a couple of studies found the HMT by computed tomographic studies [12,32]. There are two morphological possibilities when a HMT is formed: either the LGA and SA have independent aortic origins, or they have a common aortic origin – the gastrosplenic trunk (GST) [32].

We report here a HMT, characterized anatomically on computed tomography angiograms, with unusual topography of the co-existing GST, and a rudimentary arc of Bühler uniting the two trunks.

## **MATERIALS AND METHODS**

The anatomic variants reported here were found during a retrospective study of computer tomography scans, in a 62-years-old woman. Briefly, the study consisted in injecting an iodine radiocontrast agent in the left brachial vein (100 ml, with 6 ml/sec flow), followed by 50 ml iodine radiocontrast agent (Ultravist 370 mg/ml) in the brachial vein, and by 20 ml saline medium. The computed tomography was performed with a 32-slice scanner (Siemens Multislice Perspective Scanner), using a 0.6 mm collimation and reconstruction of 0.75 mm thickness with 50% overlap for multiplanar, MIP, and 3D volume rendering technique [26]. The arterial variant was documented using the Horos software and its 3D Volume Rendering application.

## **RESULTS**

The abdominal aorta (AA) coursed retroperitoneally and was deviated to the right at the level of the third and fourth lumbar vertebrae. The aortic bifurcation into the common iliac arteries was at the level of the fifth lumbar vertebra.

A gastrosplenic trunk (GST) emerged the anterior surface of the AA at 1.67 cm above the origin of the HMT. The GST runoff was from the anterior midportion of the aorta. The origin of the GST was within, and not inferior to the aortic hiatus of diaphragm, at the level of the intervertebral disc between T12 and L1 (figure 1). Just above the origin of the GST was identified an atheromatous plaque of the anterior aortic wall. The GST further branched the left gastric artery and continued with the splenic artery (figure 2). This later had a kinked and coiled morphology (figure 2). We could not find a dorsal pancreatic artery originating from the SA.

The two inferior phrenic arteries, right and left, originated independently from the posterior surface of the AA above the level of the origin of the GST.

The inferior mesenteric vein (IMV) extended toward the posterior left side of the SMA, circled the right side of the SMA, and united anteriorly with the superior mesenteric and splenic veins. It thus resulted the hepatic portal vein (PV) which inclined right abruptly towards the hilum of the liver (figure 3).

The AA was crossed anteriorly by the left renal vein at the level of the second lumbar vertebra. The HMT divided into the CHA and the SMA anterior to the left renal vein and posterior to the origin of the PV, above the pancreas. The initial segment of the CHA was

directed to the right towards the superior border of the PV, then it descended with a transpancreatic course posterior to the PV, reached its inferior/right border, and divided antero-inferiorly to the PV into the proper hepatic (PHA) and gastroduodenal (GDA) arteries. The PHA continued on the anterior side of the PV, which was thus contained within an arterial coil of the CHA and PHA. From the initial segment of the PHA left a rudimentary left hepatic artery (LHA), the left lobe of the liver being also supplied by an accessory LHA emerging from the left gastric artery. Then, the PHA continued as right hepatic artery (RHA) and was further divided in anterior and posterior branches (figure 2).

The aortic origins of the HMT and of the right renal artery were at the level of the inferior border of the first lumbar vertebra. The left renal artery emerged the abdominal aorta at the level of the superior border of the second lumbar vertebra.

The HMT and the GST had comparable lengths (table 1), and were connected by a variant of the arc of Bühler (figure 4).

## **DISCUSSION**

A combination of GST and HMT, such as in this case, was found in 1.1% [19], thus being rare. In one of the cases described in the scientific literature, the left phrenic a. branched from the GST, but in the other two the GST origin of a phrenic artery was not found [19]. Similar to our case, the phrenic arteries arose independently from the aorta. Nakamura et al (2003) documented different studies regarding the prevalence of the GST-HMT variant and found it varying from 0.4% to 1.6% [19]. A recent MDCT study on 1569 cases found the GST in 4.1% of patients [30] but it was not found any GTS associated with a HMT, such as in the present report. Uflacker (2006) indicated that the GST might associate a middle hepatic artery origin from the aorta or the SMA [31]. Wang et al (2014) listed two morphological possibilities in cases with HMT: HMT and GST, such as in this reported case, and HMT with distinct aortic origins for the LGA and SA [32].

The vertical insertion of the CT in the aortic wall is variable, as related to vertebrae, being found as high as the T11-12 intervertebral disc level [33]. Different studies reporting GSTs did not mention neither the vertebral level of origin of that trunk, nor related it with the aortic hiatus of the diaphragm [11,19]. Kahraman et al (2001) reported the origin of the GST just below the aortic hiatus [14]. In the case reported here the GST emerged within, and not

below, the aortic hiatus, which implies a degree of the GST compression during the contractions of the diaphragm. It should be considered here the median arcuate ligament syndrome in which a low insertion of the ligament or a high origin of arterial trunks may cause extrinsic compressions [22].

Different topographical patterns were indicated as possible for a CHA emerged from the HMT [10], all of them describing an exclusively ascending course of the CHA and its variable placement in relation with the hepatic portal vein and the pancreas. However none of these could be fitted with our findings, as the hepatic portal vein was horizontal and the CHA looped around it.

CHA could ascend either anterior [8,11,13,15,19], or posterior [11,19,21,27] of the PV. Higashi and Hirai (1995) described four types of HMT morphology. In types I-III the course of the CHA was posterior to the PV but in type IV the CHA ascended behind the superior mesenteric vein, passed around in front from the right side of the PV, and reached the liver [10], as found in our case.

Most HMTs were reported after anatomical dissections [1,4,5,8,9,11,13-15,19,21,23,27], the computed tomographic evidence being scarce [3,12,28,32].

A HMT could be described as a replaced CHA originating the SMA [7]. This variant correspond to Michels' ninth type of hepatic artery, in which the author indicated that the celiac hepatic artery is absent and the entire hepatic trunk derives from the SMA [18]. That variant was found by Michels (1966) in 5 from 200 dissections. There is however an incomplete correspondence of our variant and Michels' type 9 of hepatic artery. This because Michels indicated the origin of the GDA from the GST [18], while we found that the GDA left the CHA. Hicks et al (2016) indicated Michels' Type 9 of hepatic arterial anatomy by a diagram in which the GDA leaves the LGA, and not the GST, as in Michels' original diagram (1966). The GDA origin from a replaced CHA, as in our case, corresponds to Tandler's Type 5 of CT variation [29]. Therefore, Tandler's Type 5 of hepatic artery and, respectively, Michels' Type 9 of hepatic artery are reciprocally exclusive. Unlike in Tandler's Type 5 we found here an arc of Bühler uniting the GTS and HMT.

During development the segmental ventral branches of the abdominal aorta are united by longitudinal anastomoses that may either persist or disappear [11,17,24,29]. There are three known possibilities of anastomoses between the CT and the SMA, the direct one, well known and rarely reported, being the arc that Bühler described in 1904 [2,16]. We report here

a variant of the Bühler's arc that unites the GST and HMT instead of the CT and the SMA. This variant was not reported previously, at least to our knowledge.

Michalinos et al (2019) reviewed the literature regarding the arc of Bühler and discussed that, although the arc of Bühler is regarded as a remnant of Tandler's ventral longitudinal anastomosis, its embryogenesis is related to that of the dorsal pancreatic artery. This is because that artery could either originate from the SA, or from the SMA, and when both origins are maintained, an arc of Bühler results [17]. This theory is supported by the present findings: an absent dorsal pancreatic artery, seemingly replaced morphologically by a short arc of Bühler.

## **CONCLUSIONS**

Arterial variations in the celiac region are accurately identified on computed tomography angiograms. They should be evaluated by surgeons when different surgical procedures are evaluated.

## **Acknowledgements**

All the authors have equally contributed to the manuscript.

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### **Abbreviations**

- AA – abdominal aorta
- CHA – common hepatic artery
- CT – celiac trunk
- GDA – gastroduodenal artery
- GST – gastrosplenic trunk
- HMT – hepatomesenteric trunk
- IMV – inferior mesenteric vein
- LGA – left gastric artery
- LHA – left hepatic artery
- PHA – proper hepatic artery
- PV – portal vein
- RGA – right gastric artery
- RHA – right hepatic artery
- SA – splenic artery
- SMA – superior mesenteric artery
- SMV – superior mesenteric vein
- SV – splenic vein

**Table 1.** Vascular morphometry of the reported case.

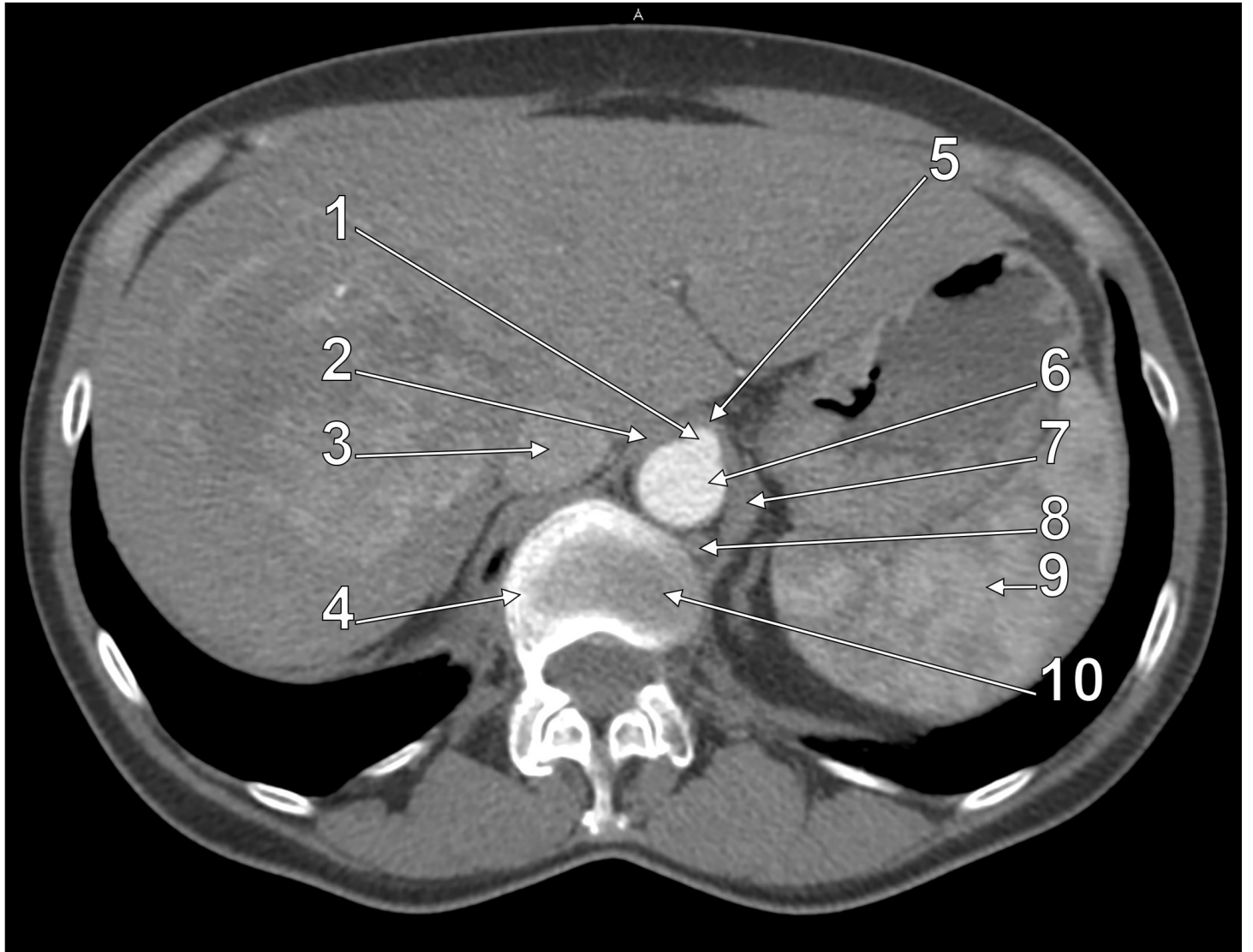
Blood vessel	Calibre (mm)	Length (cm)
Gastrosplenic trunk	5.902	2.859
Left gastric artery	1.931	
Splenic artery	5.441	
Hepatomesenteric trunk	5.49	2.983
Superior mesenteric artery	6.66	
Common hepatic artery	4.401	
Splenic vein	9.729	
Inferior mesenteric vein	9.204	
Superior mesenteric vein	8.921	
Portal vein	13.01	

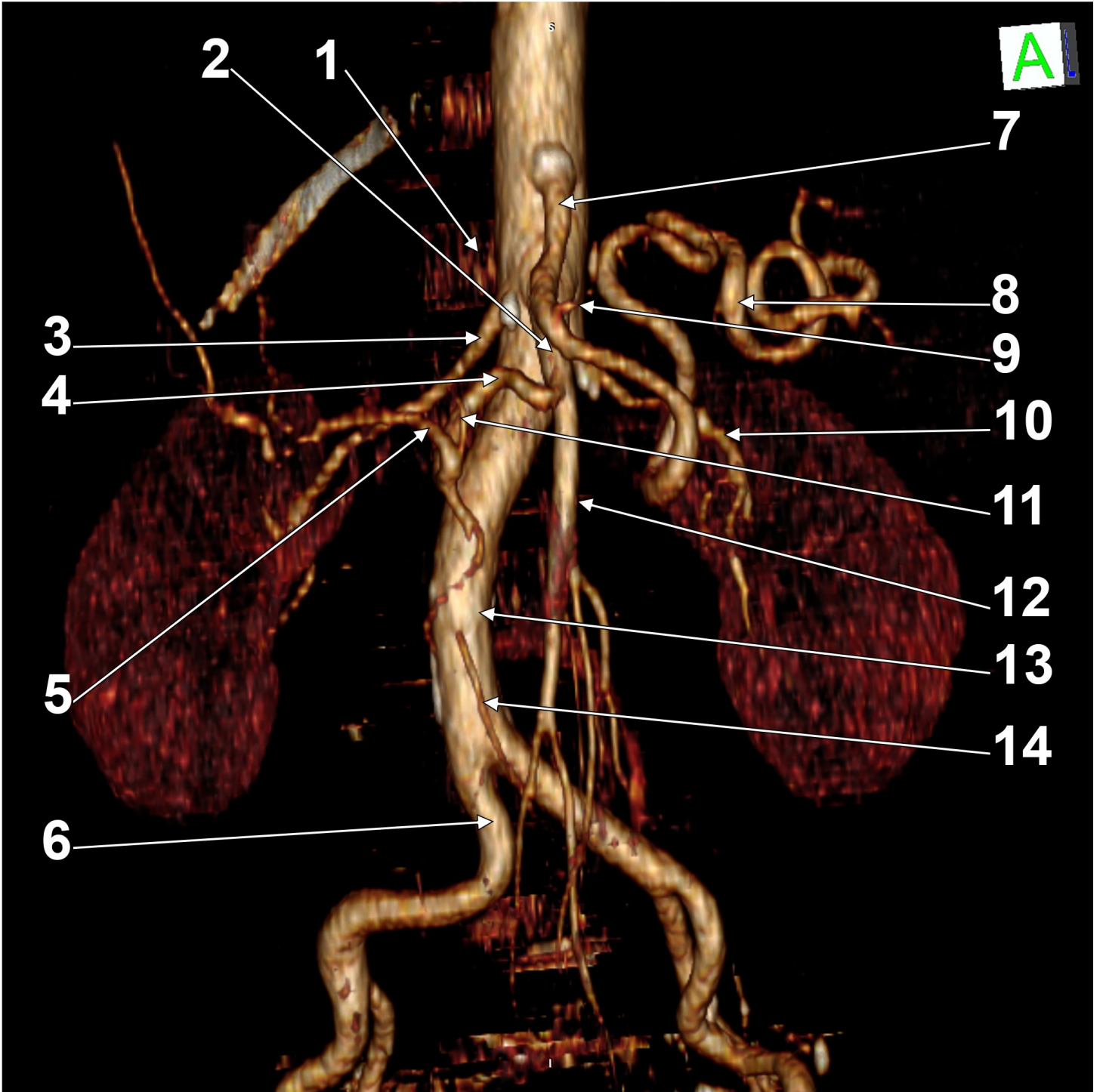
**Figure 1.** Axial CT slice through the origin of the celiac trunk which is located within the aortic hiatus of the diaphragm. 1 — celiac trunk; 2 —right pillar of the diaphragm; 3 — inferior cava vein; 4 — first lumbar vertebra; 5 — median arcuate lig.; 6 — descending aorta; 7 — left pillar of the diaphragm; 8 — hemiazygos vein; 9 — spleen; 10 — intervertebral disc between T12 and L1.

**Figure 2.** Three-dimensional volume renderization of the abdominal aorta and its branches. 1 — first lumbar vertebra; 2 — hepatomesenteric trunk; 3 — right renal a.; 4 — common hepatic a.; 5 — right hepatic a.; 6 — right common iliac a.; 7 — gastrosplenic trunk; 8 — splenic a.; 9 — left gastric a.; 10 — left renal a.; 11 — left hepatic a.; 12 — superior mesenteric a.; 13 — abdominal aorta; 14 — inferior mesenteric a.

**Figure 3.** Three-dimensional volume renderization of the hepatic portal venous system. 1 — liver (hepatomegaly); 2 — portal v.; 3 — superior mesenteric v.; 4 — right kidney; 5 — spleen; 6 — splenic v.; 7 — inferior mesenteric v.; 8 — left kidney.

**Figure 4.** Three-dimensional volume renderization (left antero-infero-lateral view, A), and MIP coronal slice (B) of the trunks emerging the upper segment of the abdominal aorta (AA). 1 — gastrosplenic trunk; 2 — arc of Bühler; 3 — common hepatic a.; 4 — superior mesenteric a.; 5 — splenic a.; 6 — hepatomesenteric trunk.





A

