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CASE REPORT

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Replaced right hepatic artery originated from splenic artery, in association with gastrosplenic trunk: a case report

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Abstract

The authors report a case of a 74-year-old woman found to have an extremely rare case highlighted by multidetector computed tomography (MDCT) angiography, with the presence of a replaced right hepatic artery (RRHA) arising from the splenic artery (SA). In this case, the SA arose from a gastrosplenic trunk (GST). The GST had an endoluminal diameter of 9.2 mm at its origin and a length of 9.3 mm. It arose directly from the anterior abdominal aortic wall, at the level of the T12–L1 intervertebral disc. The SA branched off from the GST and travelled in front of the abdominal aorta (AA) for 18.2 mm up to the level of the L1–L2 intervertebral disc. The SA then continued along an upward and tortuous path towards the splenic hilum. The inflection point of the SA trunk was located above the origin of superior mesenteric artery (SMA). The RRHA arose from the right of this inflection point. The RRHA had an endoluminal diameter of 3.0 mm at its origin and a length of 96.0 mm; it had a downward trajectory towards the hepatic hilum. The common hepatic artery (CHA) had an endoluminal diameter of 6.2 mm at origin and arose directly from the anterior wall immediately to the right of the mediosagittal plane of the AA. Knowledge of this rare anatomical variation is important for interventional radiologists, oncologists, hepatic and abdominal surgeons.

Keywords: replaced right hepatic artery, splenic artery, gastrosplenic trunk, variation, MDTC angiography.

Introduction

The intraparenchymatous distribution of the hepatic artery proper (HAP) is homologated in specialized literature [1–4]. However, anatomic variants of hepatic arterial supply are frequently encountered during anatomical dissection, radiological intervention or surgical exploration. The most widely accepted classification system for hepatic artery variations is that described by Michels [5] based on a study of 200 autopsies. In Michels' [5] series, the most common vascular variation was the replaced right hepatic artery (RRHA) that originated from the superior mesenteric artery (SMA) (type III – 11% of cases). The aberrant right hepatic artery (RHA) (replaced – RRHA and accessory – ARHA) was reported in 18% of cases collectively [5]. An aberrant RHA also represented the most frequent hepatic arterial variation in the statistical studies conducted by Hiatt *et al.* [6] and Koops *et al.* [7] (Table 1). A RRHA arising directly from: the abdominal aorta (AA) [8, 9], the celiac trunk (CT) [10, 11], the gastroduodenal artery (GDA) [8, 12], the proximal segment of the common hepatic artery (CHA) [12, 13] or the right renal artery (RRA) [14, 15], the right inferior phrenic artery (RIPA) [15], and the inferior mesenteric artery (IMA) [15] is rarely reported in the literature. The first case of RRHA originating in splenic artery (SA) was described by Caruso *et al.*, in 2016 [16]. Subsequently, De Blasi *et al.*, in 2019 [17], described another case with an RRHA originating in SA. Al Zahrani *et al.*, in 2017 [18], describes an ARHA originating in SA. All these three cases had a classic CT (hepato-gastro-splenic).

With the accelerated development of liver transplant [10] and pancreatectomy [3] method and techniques, knowledge of the anatomical variations of aberrant hepatic arteries (accessories and replaced) increases its area of interest for planning and performing high-performance surgeries.

We present the first case of a RRHA that took origin from the SA, in which the SA and the left gastric artery (LGA) – form a gastrosplenic trunk (GST). In this case report are discussed the anatomy and clinical significance of this variation of the CT and its branches.

Aim

The aim of this study is to document an unusual case of a RRHA originated from SA in association with GST by multidetector computed tomography (MDCT) angiography, and to document anatomical-surgical literature on this extremely rare anatomical variation.

Table 1 – ***Classifications of hepatic arterial variants according to Michels [5] [a] and Hiatt et al. [6] [d], in association with the percentages of hepatic arterial variation according to Michels [5] [b and f], Koops et al. [7] [c and g] and Hiatt et al. [6] [e] studies***

Type	[a] Michels [5] description	[b] Michels [5] (*n*=200 autopsies) [%]	[c] Koops *et al.* [7] (*n*=604 angiographies) [%]
I	Normal type	55.0	79.1
II	Replaced LHA from LGA	10.0	2.5
III	Replaced RHA from SMA	11.0	8.6
IV	Replaced RHA and LHA	1.0	1.0
V	Accessory LHA from LGA	8.0	0.5
VI	Accessory RHA from SMA	7.0	3.3
VII	Accessory RHA and LHA	1.0	0.2
VIII	Replaced RHA and accessory LHA or replaced LHA and accessory RHA	4.0	0.2
IX	CHA from SMA	2.5	2.8
X	CHA from LGA	0.5	0.0
	Not classified	–	1.8

Type	[d] Hiatt *et al.* [6] description	[e] Hiatt *et al.* [6] (*n*=1000 patients with liver harvesting for orthotopic transplantation) [%]	[f] Michels [5] (*n*=200 autopsies) [%]	[g] Koops *et al.* [7] (*n*=604 angiographies) [%]
I	Normal type	75.7	55.0	79.1
II	Replaced or accessory LHA from LGA	9.7	18.0	3.0
III	Replaced or accessory RHA from SMA	10.6	18.0	11.9
IV	Double-replaced pattern, RHA from SMA, and LHA from LGA	2.3	4.0	1.2
V	CHA from SMA	1.5	2.5	2.8
VI	CHA from AA	0.2	0.0	0.0
	Not classified	–	2.5	2.0

CHA: Common hepatic artery; LGA: Left gastric artery; LHA: Left hepatic artery; RHA: Right hepatic artery; SMA: Superior mesenteric artery.

Case presentation

A 74-year-old woman, with a past medical history of arterial hypertension, infrarenal abdominal aortic aneurysm and peripheral arterial occlusive disease of the lower limbs, was examined at Neuromed Diagnostic Imaging Centre (Timişoara, Romania) using MDCT angiography (64-slice MDCT system, SOMATOM Sensation, Siemens Medical Solutions, Forchheim, Germany) to map her infra-diaphragmatic arterial tree and to assess any changes from the previous examination carried out a year earlier. The patient had *in situ* a functional aortoiliac prosthetic graft used to manage her infrarenal aortic aneurysm. Imaging also revealed in addition that the patient had a RRHA that arose from the SA, and a GST with independent origin of the CHA from the AA (Figure 1; Figure 2, A and B). Extensive imaging examination reveal in addition the presence of a RIPA originated from the proximal segment of LGA and left inferior phrenic artery (LIPA) originated directly from AA.

The CHA had an endoluminal diameter of 6.2 mm at origin and arose directly from the anterior wall immediately to the right of the mediosagittal plane of the AA. The CHA originated 24.2 mm above the origin of the SMA at the level of the upper one-third of the L1 vertebral body. The CHA traveled a short downward distance ventral to the AA (14.7 mm) before becoming oriented in the horizontal plane to the right of the AA. The CHA continued another 58.6 mm before it divided into the left hepatic artery (LHA) and GDA. The GST had an endoluminal diameter of 9.2 mm at its origin and a length of 9.3 mm. It arose directly from the anterior AA wall, immediately to the left of the mediosagittal plane of the AA, at the level of the T12–L1 intervertebral disc. The LGA had an endoluminal diameter of 3.2 mm at its origin and arose from the right edge of the GST and travelled adjacent to the SA for 11.0 mm. The LGA then travelled upwards to the lesser curvature of the stomach.

The SA branched off from the GST and travelled in front of the AA for 18.2 mm up to the level of the L1–L2 intervertebral disc. The SA then continued an upward and tortuous path towards the splenic hilum. The inflection point of the SA trunk was located above the origin of SMA. The RRHA arose from the right of this inflection point. The RRHA had an endoluminal diameter of 3.0 mm at its origin and a length of 96.0 mm and had a downward trajectory towards the hepatic hilum. In the first one-third of its path (43.2 mm), the RRHA passed in front of the AA between the CHA and the splenic vein. The RRHA then traveled anterior to the head of the pancreas and posterior to the trunk of the portal hepatic vein (PHV) (17.7 mm). In the last third of its path (35.1 mm), the RRHA with a slight upward displacement, passed under the terminal segment of the PHV and the right branch of the PHV before it divided into its anterior and posterior branches (segments V–VIII).

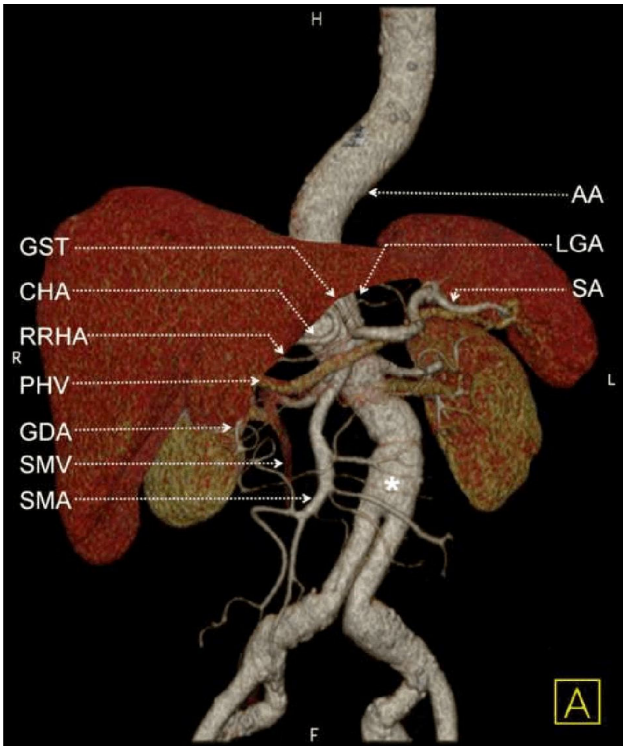

Figure 1 – ***MDCT angiography of the AA and his branching pattern. The 3D VRT image revealed the presence of the GST, the origin of RRHA from SA and the presence of an in situ functional aortoiliac prosthetic graft. 3D: Three-dimensional; AA: Abdominal aorta; CHA: Common hepatic artery; GDA: Gastroduodenal artery; GST: Gastrosplenic trunk; LGA: Left gastric artery; MDCT: Multidetector computed tomography; PHV: Portal hepatic vein; RRHA: Replaced right hepatic artery; SA: Splenic artery; SMA: Superior mesenteric artery; SMV: Superior mesenteric vein; VRT: Volume rendering technique; *: Level of in situ of a functional aortoiliac prosthetic graft.***

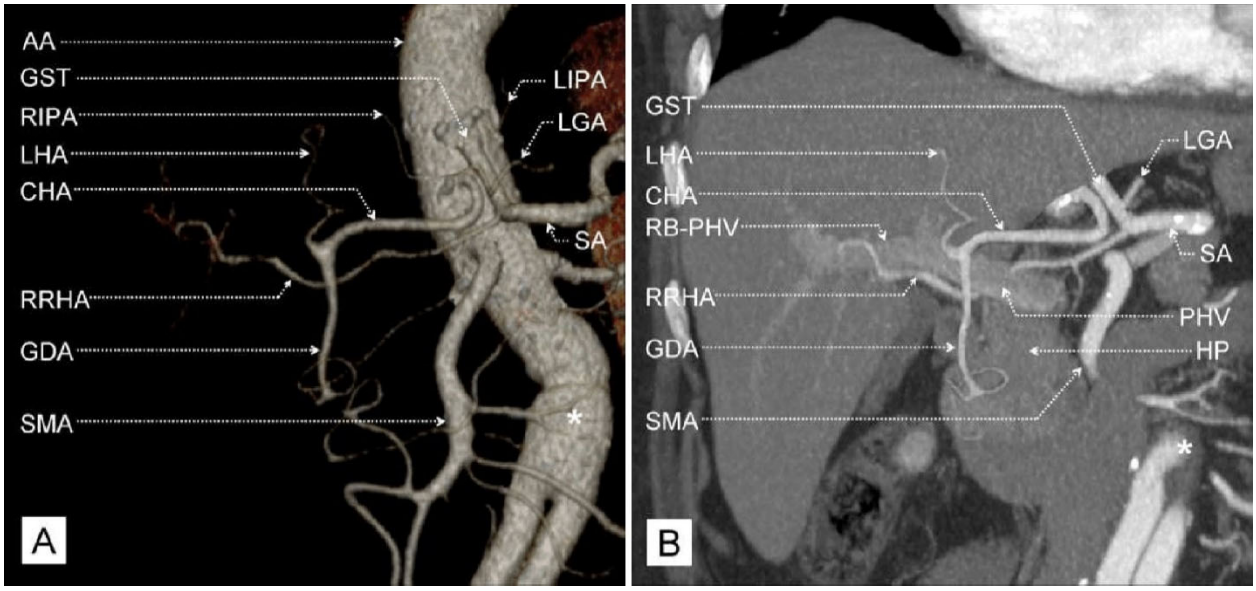

Figure 2 – ***MDCT angiography of the AA, GST, CHA and RRHA. The 3D VRT (A) and MIP (B) images of AA revealed a GST in association with a CHA independently arising from the AA and the RRHA arising from the phrenic artery. 3D: Three-dimensional; AA: Abdominal aorta; CHA: Common hepatic artery; GDA: Gastroduodenal artery; GST: Gastrosplenic trunk; HP: Head of pancreas; LGA: Left gastric artery; LHA: Left hepatic artery; LIPA: Left inferior phrenic artery; MDCT: Multidetector computed tomography; MIP: Maximum intensity projection; PHV: Portal hepatic vein; RB-PHA: Right branch of portal hepatic vein; RIPA: Right inferior phrenic artery; RRHA: Replaced right hepatic artery; SA: Splenic artery; SMA: Superior mesenteric artery; VRT: Volume rendering technique; *: Level of in situ functional aortoiliac prosthetic graft.***

Consent

For the angiographic examination by using a 64-slice MDCT system, and of iodinated contrast agents in accordance with the investigation protocol, a written informed consent was signed by the patient. Also, a written informed consent has been requested from the patient for publication of this case report with accompanying images. The study was also approved by the Ethics Commission of Scientific Research of the Victor Babeş University of Medicine and Pharmacy Timişoara, Romania (Approval No. 26/2019).

Discussions

The gastrosplenic trunk

Prevalence

Song *et al.* [19], on 5002 cases, using spiral computed tomography and digital subtraction angiography, revealed

normal anatomy of the CT in 89.1% of cases, and 9.6% of cases with anatomical variations. In the group of anatomical variations, 14 morphological types were highlighted, the GST associated with the separate origin of the CHA from AA being present in only 0.22% of cases.

Embryology

According with Iacob *et al.* [20], the anatomical variations of the CT, SMA and IMA are due to developmental changes in the ventral segmental arteries. In the early stages of embryo-fetal development, (after the 4th and 5th weeks), the four primitive roots of the ventral segmental arteries (10th–13th ventral segmental arteries) become, (from top to bottom), the LGA, SA, CHA and SMA, respectively. The 10th, 11th, 12th and 13th ventral segmental arteries are united by "longitudinal anastomosis". Depending on the degree of the extent of the resorption/ retention of some parts of the longitudinal anastomosis and these four ventral segmental roots, many anatomical variants of CT and SMA develop [20–27]. In our case: (*i*) the cranial part of the longitudinal anastomosis (part between the 10th and the 11th ventral segmental arteries) persist; (*ii*) the distal part of the longitudinal anastomosis (part between the 11th and the 13th ventral segmental arteries) regresses; (*iii*) the root of the 11th ventral segmental artery regresses; (*iv*) the distal part of the 11th ventral segmental artery root regresses; (*v*) the distal part of the 11th ventral segmental artery connects with the 10th ventral segmental artery to form the GST; (*vi*) the persistence of the third root of the ventral segmental arteries leads to the appearance of the CHA, with independent arising from the AA; (*vii*) the persistence of the fourth root of the ventral segmental arteries leads to the appearance of the SMA, with independent arising from the AA.

Classification and clinical implications

The GST represents type III of Morita's classification (1935), characterized by the presence of a common trunk formed by LGA and SA, associated with the independent origin of CHA in AA [20]. It represents one of the common anatomical variations of the CT, having in the statistics of Torres *et al.* [28] a frequency of 4.1%. The GST is included as type II (in Lipshutz's classification, 1917), type VI (in Adachi's classification, 1928), type V (in Michael's classification, 1955) and type V (in Uflacker's classification, 2007) [29–31]. The GST associated with the hepatomesenteric trunk (HMT) represents type IV' from Morita's classification, characterized by the presence of two incomplete common trunks, the first consisting of LGA and SA (the GST), the second consisting of CHA and SMA (the HMT); it is one of the common anatomical variations of CT and SMA (2.64% of cases) [19]. The presence of the GST causes SA to become the main arterial trunk derived from CT. Traumatic or iatrogenic injury of GST origin severely affects the vascularization of the stomach and spleen. In our case, the GST, (which gives rise to the first part of the route or to LGA and RRHA and then continues with SA), becoming the main arterial source for the organs of the supramesocolic floor of the abdomen (stomach, right half of the hepatic parenchyma and spleen).

Replaced right hepatic artery

Prevalence

On a large series of cases (10 966 cases from 21 studies), Liang *et al.* [32] revealed the standard anatomy of hepatic vascularization in 67.2% of cases. The presence of ARHA is revealed in 6.8% of cases, and RRHA in 9.7% of cases. Within the latter group, the origin of RRHA was highlighted as a percentage of: (*i*) 9.2% of cases in the SMA; (*ii*) 0.3% of cases from CT; (*iii*) 0.07% of cases in CHA; (*iv*) 0.07% of cases from GDA; (*v*) 0.07% from AA; (*vi*) 0.01% of cases from LGA; (*vii*) 0.01% of cases from RIPA; (*viii*) 0.01% of cases from IMA. In the case series analyzed by Liang *et al.* [32], no case of RRHA with origin in SA was highlighted. Two case reports have been published in which a classical CT is present, and RRHA originates in SA [16, 17].

Embryology

According to Gillot (1966), as quoted by Douard *et al.* [33], the primitive liver can be divided into three sections: a middle, lateral left, and lateral right part. Each of these sections are supplied by primitive hepato-digestive arteries: (*i*) embryonic LHA, from the LGA services the segments II and III; embryonic middle hepatic artery, from the CHA services the segments IV, V and VIII; embryonic RHA, from the omphalomesenteric artery (upcoming SMA) services the segments VI and VII [34]. In the embryo-fetal development, these three embryonic arteries are connected at the level of the hepatic hilum by the longitudinal anastomosis, and afterwards, the embryonic RHA and LHA regress. Usually remain only the HAP, from CHA, from CT [2, 33, 35, 36]. The proximal part of the aberrant (replaced or accessory) LHA originated from LGA, is usually formed from a persistence of the longitudinal anastomosis neighboring the LGA. The proximal part of the aberrant (replaced or accessory) RHA originated from SMA, is usually formed due to a persistence of the longitudinal anastomosis between the 3rd and 4th root that remains connected only to the 4th root (future SMA) [34]. In our case: (*i*) the embryonic LHA originated from LGA regresses; (*ii*) the arteries of segments II and III are connected to the distal part of the embryonic middle hepatic artery; (*iii*) the embryonic middle hepatic artery persists and is initially distributed to segment IV and then connected to the arteries of segments II and III; (*iv*) the origin of the RRHA in our case (originated from SA) could have developed from a remnant of the longitudinal anastomosis instead between the 2nd and 3rd roots that remain connected only to the 2nd root (the future SA); it will serve through segmental branches, segments V–VIII.

Classification and clinical implications

The most important factors that can complicate the performing in good conditions the surgical procedures of the duodenum-pancreatic sphere are the variability of the origin and the path of RRHA as well [37]. The variability of the RRHA origin was analyzed on a number of 6588 cases (from 10 literature studies) by Yamashita *et al.* [38]; the authors highlight a number of seven levels of RRHA origin, which in the order of frequency are: (*i*) SMA

(12.95% of cases); (*ii*) CT (0.24%); (*iii*) AA (0.15%); (*iv*) CHA (0.15%); (*v*) GDA (0.045%); (*vi*) LGA (0.015%); and (*vii*) RRA (0.015%). Isolated cases of particular origins of RRHA were leveled at: SA [16, 34]; RIPA [9]; and IMA [9]. Knowledge of the RRHA pathway and its relationships with the pancreatic head parenchyma are essential in the safe planning and implementation of cephalic pancreaticoduodenectomy [39]. Studies by Jah *et al.* [37] highlighted three types of the RRHA pathways in relation to the head of the pancreas: (*i*) postero-lateral pathway to the head of pancreas; (*ii*) intra-pancreatic pathway (intraparenchymal); (*iii*) path located within superior mesenteric vein grove. In our case, RRHA has an initial path located anteriorly to AA and inferior to CHA and then superior to the pancreatic head and posteriorly to the trunk of the PHV, in the distal portion having a slight ascending path with the position of the arterial trunk lower to the right branch of PHV and 1/3 distal to the PHV trunk. This type of RRHA pathway does not fit with the types of classification described by Jah *et al.* [37] and therefore constitute a new morphological type.

The study of the three-dimensional (3D) spatial distribution of the vaso-ductal elements can be carried out by: (*i*) classical dissection [32, 40], (*ii*) by making and examining corrosion casts [41], (*iii*) by making two-dimensional plastination preparations followed by 3D reconstruction of anatomical structures and [42, 43]; (*iv*) by modern imaging methods, of which MDCT angiography is the easiest method [19, 20, 24–26, 38, 44].

At the present stage of the development of imaging examination techniques in the medical research field, MDCT angiography represents the most performing examination method for highlighting on significant batches of study the vascular variations, followed by their storage and archiving; the review is carried out without problems.

Conclusions

This study presents an extremely rare case of a RRHA that took origin from the SA, in which SA and LGA form a GST, in association with CHA arising independently from the AA. The MDCT angiography shows high sensitivity in highlighting such rare anatomical variations. Highlighting the variations in the CT branching pattern is essential for the successful completion of the practiced interventions in the medical surgical practice.

Conflict of interests

The authors declare that they have no conflict of interests.

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