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ANATOMIC VARIATIONS

Right hepatic artery from splenic artery: the four-leaf clover of hepatic surgery

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Abstract The anatomy of hepatic arteries is one of the most variable. Accurate awareness of all the possible anatomic variations is crucial in the upper GI surgery and especially in liver and pancreas transplantation. The most frequent anatomical variants are: a replaced or accessory right hepatic artery (RHA) from the superior mesenteric artery (6.3–21 %), a replaced or accessory left hepatic artery (LHA) from the left gastric artery (LGA) (3–18 %) or a combination of these two variants (up to 7.4 %). Herein, we describe the case of a 67-year-old cadaveric organ donor who presented a RHA originating from the splenic artery (SA) associated with both a CHA originating from the celiac trunk (CT) and a LHA originating from the LGA.

Keywords Hepatic artery variant · Hepatic anatomy · Hepatic vascular anatomy

Abbreviations

CHA	Common hepatic artery
RHA	Right hepatic artery
LHA	Left hepatic artery
SA	Splenic artery
LGA	Left gastric artery
CT	Celiac trunk
SMA	Superior mesenteric artery
PV	Portal vein

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Introduction

The anatomy of hepatic arteries is one of the most variable. Accurate awareness of all the possible anatomic variations is crucial in the upper GI surgery and especially in liver and pancreas transplantation. Liver is usually vascularized by the common hepatic artery (CHA) that originates from the celiac trunk (CT) and is divided into a right and a left branch (51–85.1 %) [1, 3–28].

The most frequent anatomical variants are: a replaced or accessory right hepatic artery (RHA) from the superior mesenteric artery (SMA) (6.3–21 %), a replaced or accessory left hepatic artery (LHA) from the left gastric artery (LGA) (3–18 %) or a combination of these two variants (up to 7.4 %) (Table 1).

Herein, we describe the case of a 67 years old cadaveric organ donor who presented a RHA originating from the splenic artery (SA), associated with both a CHA originating from the celiac trunk (CT) and a LHA from the LGA. A detailed review of the literature on vascularization of the liver was carried out.

Materials and methods

We performed a review of the literature on Pubmed, Embase and Web of Knowledge using the following keywords: "hepatic artery variant", "hepatic artery",

Table 1 Description of anatomy of hepatic arteries in 27 selected articles reporting well detailed series according to Hiatt's classification

Author. Year	Patients	Normal (%)	LHA from LGA (%)	RHA from SMA (%)	RHA + LHA (%)	CHA from SMA (%)	CHA from aorta (%)	Others (%)
Michels [19]	200	55.0	18.0	18.0	4.0	4.5	0.0	0.5
Suzuky [26]	200	53.5	12.5	7.5	4.5	3.0	0.0	19.0
Niederhuber [20]	111	72.1	9.9	10.8	1.8	0.0	0.0	5.4 (1 case LHA from SA)
Kemeny [14]	100	59.0	17.0	18.0	2.0	3.0	1.0	0.0
Rygaard [22]	216	75.5	4.6	13.4	1.9	1.4	0.0	3.2
Rong [21]	120	51.0	12.0	21.0	Unknow	5.0	1.0	10.0
Curley [6]	180	72.2	13.9	12.8	1.1	0.0	0.0	0.0
Makisalo [18]	100	76.0	4.0	7.0	5.0	3.0	0.0	5.0
Hardy [12]	70	61.5	7.1	10.0	7.1	0.0	4.2	10.1 (2 cases LHA from SA)
Burke [3]	74	85.1	6.8	8.1	0.0	0.0	0.0	0.0
Hiatt [13]	1000	75.7	9.7	10.6	2.3	1.5	0.2	0.0
Soin [24]	527	69.0	14.3	8.3	2.5	2.3	0.2	3.4
De Santis [8]	150	52.0	10.6	17.3	1.2	4.0	0.0	14.7
Gruttadauria [10]	701	57.7	11.5	14.9	7.4	0.9	0.4	7.2
Covey [5]	600	61.3	14.5	10.2	4.5	2.0	0.0	7.5
Allen [1]	265	63.0	14.0	7.2	3.0	Unknown	Unknown	12.8
Koops [15]	604	79.1	3.0	11.9	1.4	2.8	0.0	1.8
Varotti [27]	96	70.8	12.5	13.5	2.1	1.1	0.0	0.0
Stemmler [25]	63	80.9	7.9	6.3	3.2	1.6	0.0	0.0
Coskun [4]	48	54.1	16.6	8.4	4.2	0.0	0.0	16.6
Winston [28]	371	51.0	12	15	Unknown	2.0	2.0	18.0
Lopez-A. [16]	1081	70.0	13.6	8.4	4.0	2.5	0.7	0.3
De Cecco [7]	250	66.0	10.4	13.2	4.6	2.0	0.0	3.3
Egorov [9]	350	56.3	12.3	17.7	4.0	2.6	2.8	4.3
Saba [23]	1629	61.4	14.2	17.5	3.9	1.6	0.3	1.1
Gumus [11]	820	66.8	12.0	13.5	4.2	1.8	0.0	1.5
Loschner [17]	1267	72.2	13	7.9	2.8	2.0	0.3	2.1

"right hepatic artery", "hepatic vascularization". Italian, English and French language articles were selected without temporal limits. We found 1245 articles matching the above keywords. The objectives of the review were to describe the frequency of hepatic artery variants and to evaluate the presence of previous reports describing RHA off SA. We used the accuracy of anatomical description of celiac axis and hepatic arteries as the principal criteria to select articles. By analysing the abstracts of the articles, we selected 41 retrospective papers. 27 articles detailed satisfactorily the anatomical variants, with clear numbers and percentages according to the most common classifications. In addition, we searched for case reports describing the celiac and hepatic anatomy. We found 156 case reports/little case series which treated the above matter.

Case report

In May 2014, an en-bloc abdominal procurement (liver, pancreas in toto, spleen, aorta patch with CT and SMA origin) was sent from an external surgery team to the Liver transplant Unit of Ospedale Maggiore Policlinico di Milano. The procurement was performed on a 67 year old cadaveric organ donor. During the dissection manoeuvres at back table, we found a RHA originating from the splenic artery, associated with a CHA originating from the celiac trunk and a LHA from the LGA (Fig. 1).

In the case being analysed the CT was divided in SA, CHA and LGA without the presence of hepatic vessels from SMA. The distance between CT and SMA was 1.1 cm. The diameter of the right hepatic artery was 3–4 mm; it originated from the splenic artery, 4 mm after

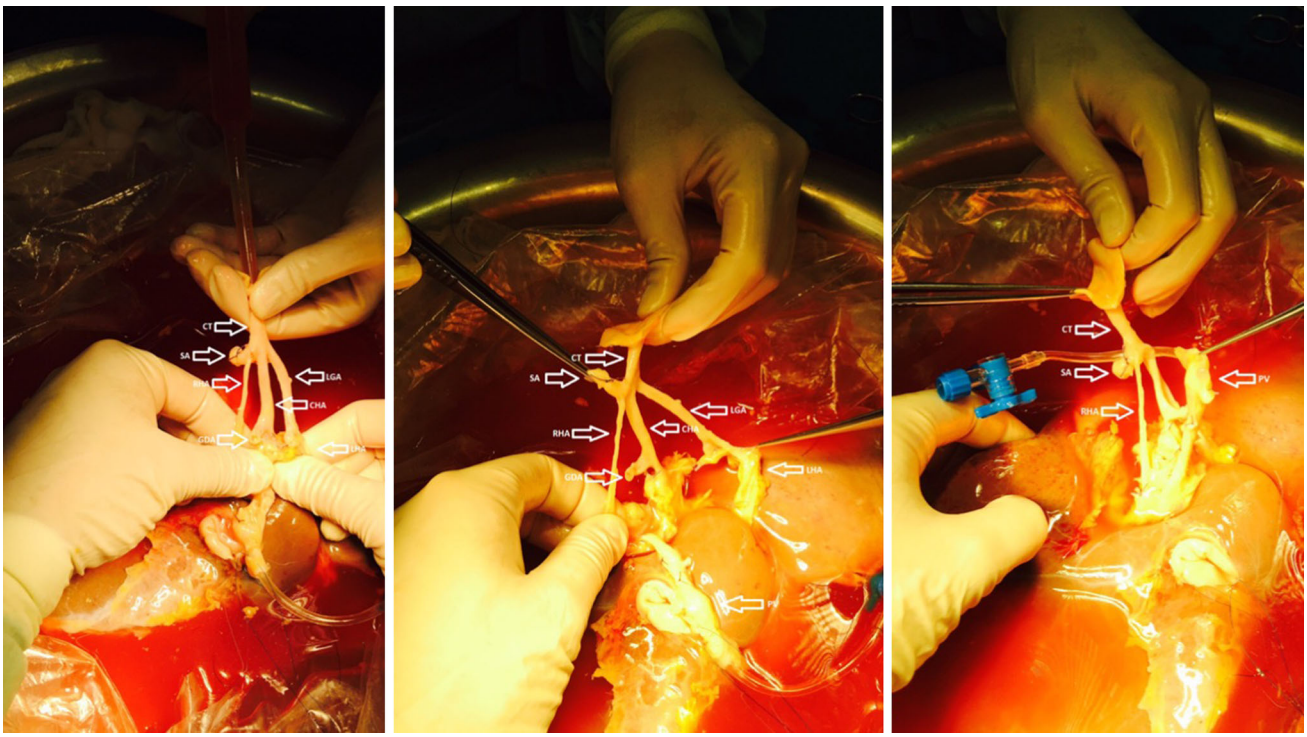

Fig. 1 Pictures of the liver on back table. *CT* Celiac trunk, *SA* splenic artery, *RHA* right hepatic artery, *CHA* common hepatic artery, *GDA* gastroduodenal artery, *LHA* left hepatic artery, *LGA* left gastric artery, *PV* portal vein

the CT division. The right hepatic artery's course was downward and parallel in respect of the common hepatic artery, at the top of the pancreas. It then moved behind the gastroduodenal artery and the bile duct. Finally it goes up at the right side of the portal vein, which is the standard anatomical position of the RHA off the superior mesenteric

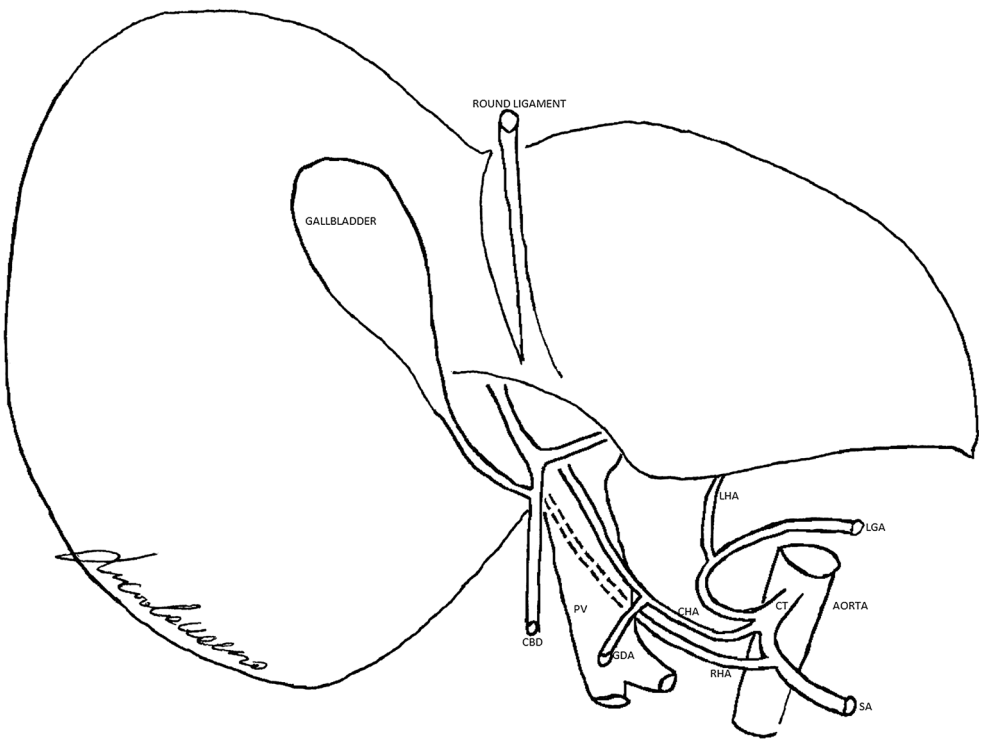

Fig. 2 Schematic description of the hepatic artery variant. *CT* Celiac trunk, *SA* splenic artery, *RHA* right hepatic artery, *CHA* common hepatic artery, *GDA* gastroduodenal artery, *LHA* left hepatic artery, *LGA* left gastric artery, *CBD* common bile duct, *PV* portal vein

artery (Fig. 2). The course of the LHA from the LGA was standard. No arterial reconstructions on back table were needed. During liver transplantation the arterial anastomosis was performed between the donor CT and the recipient CHA. Our patient was discharged on XV post-operative day after a regular course.

Discussion

The definition of anatomical variant is used to define the morphology of a particular structure which deviates from the anatomical configuration observed in the majority of individuals. Therefore, the anatomical variant is a change from the normal or modal configuration. Although not pathological, anatomical variants may make diagnostic or operative procedures more complex. Changes in hepatic vascularization were first defined by Michels' classification [19] who in 1962 described ten types of arterial variants. Rarer cases include a CHA from SMA and a CHA which arises from LGA. A more simple and recent classification was proposed by Hiatt et al. [13] in 1994.

The prevalence of hepatic artery variants outside these two classifications was reported between 0 and 19 % (Table 1).

We analysed 27 works with a total of 11.193 hepatic artery anatomy descriptions [1, 3–28].

The analysis of the literature highlighted a high variability in hepatic vascularization (14.9–49 %) which may arise in different combinations: from celiac trunk or one of its branches, from the SMA and/or directly from the aorta. The splenic artery is the arterial branch of the celiac trunk which is the less interested in liver vascularization.

From the analysis performed we found three cases of left hepatic artery arising from the splenic artery. None of the 27 papers we analysed (Table 1) reported a right hepatic artery originating from the splenic artery. Even among the 156 case reports and little case series no evidence of this variant was found. Moreover, we became aware of a recent Russian analysis of 4315 angiographic evaluations, not reported in Table 1 because it was presented at the GEST 2014 congress (Balakhnin PV et al. Classification of hepatic artery anatomic variants for intra-arterial therapy: analysis of 4315 angiographic studies. GEST 2014, poster session). Even in this large series of cases the origin of a RHA from SA was absent.

Conclusions

The presence of a RHA from the SA is very rare: whilst we are aware that it is not possible to say with certainty that all scientific contributions in every language from every country have been taken into account, as far as we know, this case report appears to be the first describing this kind of variant. We analysed more than 11,000 cases reporting hepatic artery anatomy before finding a RHA off the SA. It has been estimated that there are approximately 11,000 three-leaf clovers for every four-leaf clover [2]. What an interesting similarity.

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Compliance with ethical standards

Conflict of interest The authors declare that no conflict of interest exists.

Ethical standards All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Informed consent Informed consent was obtained from all patients for being included in the study.
Additional informed consent was obtained from all patients for which identifying information is included in this article.
All institutional and national guidelines for the care and use of laboratory animals were followed.

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