Journal of Surgery
Kim E, et al. J Surg 7: 1582
www.doi.org/10.29011/2575-9760.001582
www.gavinpublishers.com

Case Report

Replaced Common Hepatic Artery Variations: Anatomical Considerations and Implications for Surgery: A Review and Case Report

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Citation: Kim E, Klansek J, Lashley K, Granite G, Dupont J, et al. (2022) Replaced Common Hepatic Artery Variations: Anatomical Considerations and Implications for Surgery: A Review and Case Report. J Surg 7: 1582. DOI: 10.29011/2575-9760.001582

Received Date: 21 September, 2022; **Accepted Date:** 23 September, 2022; **Published Date:** 26 September, 2022

Abstract

Cadaver organ donors have been an excellent resource for studying vascular systems since precise anatomical details can be identified and assessed. From these studies over the past several decades, anatomical variations have been categorized into classification and modeling systems. These systems have been used as procedural guides and planning by anatomists, surgeons and interventional radiologists. This has helped to predict and strive for optimal surgical and clinical outcomes, as well as help reduce procedural complications associated with anatomical knowledge deficiencies. Aberrations of the celiac trunk have been studied quite extensively because it is generally prone to variations and because of its juxtaposition and contribution to the pancreas, liver, duodenum and hepatic biliary tree. Six of the common classification systems currently used by surgeons and interventional radiologists include those created by Lipshutz, Adachi, Morita, Uflacker, Hiatt and Michels. All six classification systems acknowledge the rare variant characterized by a common hepatic artery arising from the superior mesenteric artery, which is referred to as the replaced common hepatic artery or the celiacomesenteric trunk. This variant can have significant clinical implications owing to its proximity to the pancreatic head. As imaging modality advancements continue to evolve, it is expected that anatomical modeling will also likely enhance. We are entering a time when more centralized and cohesive arterial classification systems are needed to help further our understanding of vascular variant patterns.

Keywords: Celiac trunk variation, Michel's classification; Replaced common hepatic artery

Introduction

There are five main branches that arise from the abdominal aorta to supply the abdominal viscera. These include the Celiac Trunk (CT), Superior Mesenteric Artery (SMA), left and right renal arteries, and Inferior Mesenteric Artery (IMA). Organs of the foregut are supplied mostly by the CT, while the midgut and the hindgut are supplied by the SMA and IMA, respectively. [1] The normal anatomy of the CT includes three main divisions: the Splenic Artery (SA), Common Hepatic Artery (CHA) and the Left Gastric Artery (LGA). In most cases, the CHA then divides into the Gastroduodenal Artery (GDA) and the Proper Hepatic Artery (PHA). Variations of the CT have been studied quite extensively by anatomists and specialists in medical fields because of its juxtaposition and contribution to the pancreas, duodenum and hepatic biliary tree. Variations have been studied as early as the eighteen hundreds by Swedish scientist Albrect von Haller. Haller's anatomical atlas, published in parts between 1743 and 1756, provides the first glimpse of CT variations. [2] Lipshutz, Adachi, Morita, Uflacker, Hiatt and Michels are among others who generated more recent models and widely utilized classification systems of CT aberrations. Understanding and elucidating these variations and patterns commonly seen in vascular anatomy can highlight anatomical intricacies and help with preoperative surgical planning. Michels model is perhaps one of the most widely used classification systems implemented by surgeons today. This model demonstrates that in a limited number of cases, the CHA branches off of the SMA, which has been classified as the Type IX CT variant [3]. When the CHA arises from the SMA, it can be prone to injury, especially during cases involving Pancreatoduodenectomy (PD). This case and review aims to describe this variation to further our understanding of its surgical implications in performing procedures, such as PD.

Case Report

During routine cadaveric dissection of sixty-five human donors in the 2020-2021 first-year medical gross anatomy course and 2021 graduate nursing advanced anatomy course at the Uniformed Services University of the Health Sciences (USUHS), a Replaced Common Hepatic Artery (RCHA) was identified on a 70-year-old White male patient with a cause of death of pneumonia. The postmortem cadaveric study revealed important anatomical variations arising from the abdominal aorta and more specifically, from the CT [4]. The variations were then documented and subsequently compared to the normal expected variations reported in the literature. Table 1 provides a brief description of each variation included in Michels classification. [5] Figure 1 is a posterior view artistic rendering of the CHA coursing off the SMA with the CT in place giving rise to the LGA and SA (and note the absent CHA branch coming off the CT). Figure 2 is a cadaveric image providing a closer look at the CHA identified in this particular case, noting its close proximity to the pancreatic head and coursing behind the pancreas, which is the more common presentation of the RCHA variation. Figure 3 shows a cadaveric image indicating the unique RCHA path – coursing up from the pancreas and behind the portal vein. Figure 4 is a digital image representing the RCHA in this case; the path of the artery is clearly depicted.

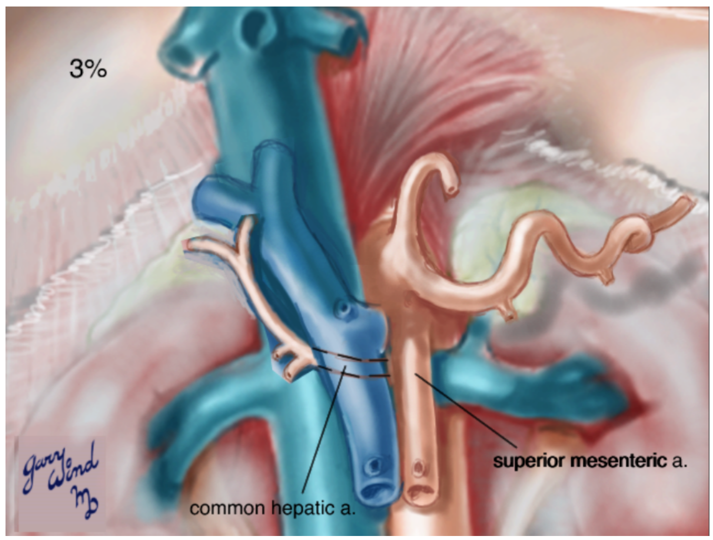

Figure 1: A posterior view (artistic rendering) of the CHA coursing off the SMA with the CT in place giving rise to the LGA and SA (and note the absent CHA branch coming off the CT indicating Michel Type 9 variant. CHA: Common Hepatic Artery, SMA: Superior Mesenteric Artery Accessory (Acknowledgement: Thank Dr. Gary Wind for this artistic contribution. More images can be found on his educaqtion website at http://www.vesalius.com/about.asp).

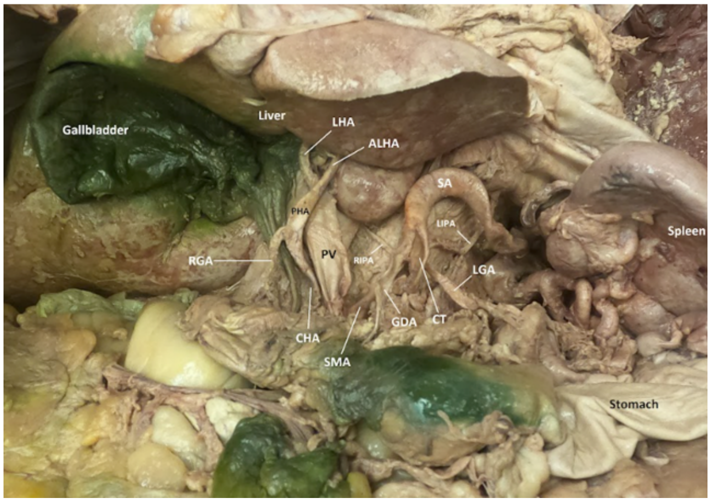

Figure 2: Presentation of the CHA on routine dissection showing its replaced course off the SMA. Also shown is the celiac trunk with the LGA and SA branches (note the absent CHA). CHA: Common Hepatic Artery, SMA: Superior Mesenteric Artery, SA: Splenic Artery, LGA: Left Gastric Artery - (note the white outline showing the artery's close proximity to the pancreatic head and coursing behind the pancreas, which is the more common presentation of this replaced vasculature).

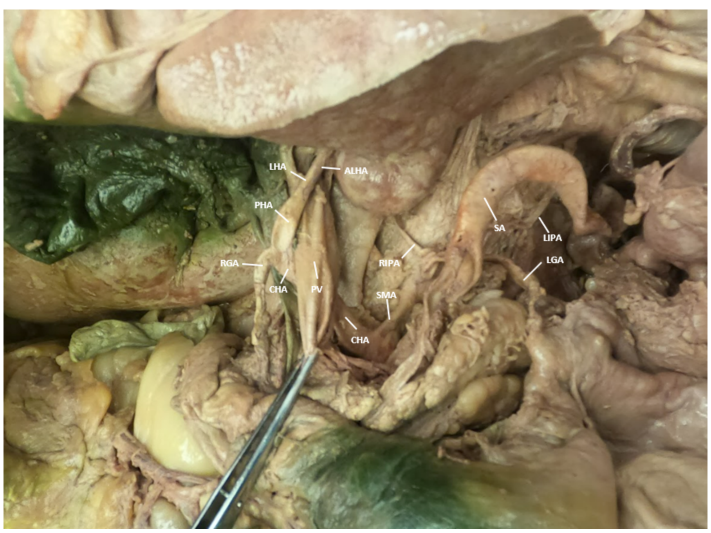

Figure 3: A post-dissection cadaveric image indicating the unique RCHA path, coursing up from the pancreas and behind the portal vein.

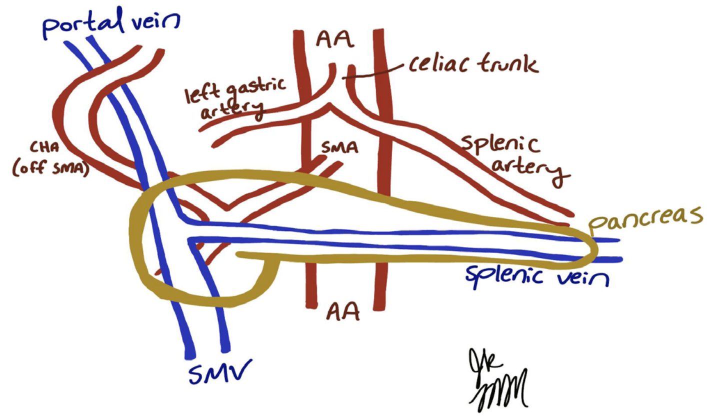

Figure 4: Digital image representing the RCHA in this case; the path of the artery is clearly depicted.

Variation #	Vascular Description/Observation
I	Classic anatomy
II	Replaced LHA arising from LGA
III	Replaced RHA arising from SMA
VI	Replaced LHA and replaced RHA
V	Accessory LHA from LGA
VI	Accessory RHA from SMA
VII	Accessory LHA and RHA
VIII	Replaced RHA and accessory LHA or replaced LHA and accessory RHA
IX	Entire Hepatic trunk arising from SMA
X	Entire Hepatic trunk arising from LGA

Table 1: Brief descriptions of each variation included in Michel's classification.

Discussion

Anatomical differences and variations in vascular patterns can arise during embryonic development. Normally, in the head and neck region, arterial patterns of the aorta arise mainly from six structural pairs of aortic arches that course through the pharyngeal arches. The branches found throughout the rest of the body (the descending aorta and below), arise mainly from structures referred to as the right and left dorsal aortae. [6] The pair of aortae fuse and eventually give rise to posterolateral arteries, lateral arteries, and ventral arteries also known as the vitelline arteries. The ventral branches eventually give rise to the CT, SMA, and IMA. [7] Development of the CT and its branches: LGA, SA, CHA, as well as the SMA are characterized by a longitudinal ventral anastomotic connection. [8] The anastomosis between the CT and the SMA typically regresses, resulting in complete separation of the two arteries. [8] However, in some cases, the anastomosis does not regress or continues to grow, resulting in the various anatomical variations of the CT and SMA. [8] Throughout development, the events involved in vascular formation are highly organized and affected by spatial and temporal expression of gene sets. [9] Currently, a substantial amount of research goes into understanding the molecular mechanism that regulates and determines the growth pattern of the vascular system [9].

The clinical implications of vascular anomalies have been studied quite extensively and reported in the literature. Because of the complex vasculature surrounding the pancreas, liver, and duodenum, treatment of cancerous lesions within this area can require advanced preoperative diagnostic imaging and advanced surgical expertise to effectively identify vascular nuances or vascular anomalies if they occur. Although rare, the Michel Type IX celiac trunk variant characterized by the CHA arising from the SMA has been observed by anatomists, surgeons and interventional radiologists at a rate of 0.4 to 4.5 % [10]. Characteristically, this variant has significant clinical relevance owing to its proximity to the head of the pancreas. In particular, since the branching of the SMA occurs at the level of the pancreatic head, any type of surgical procedure in this area can risk injury to the surrounding vasculature and structures. Special precautions are needed in these situations since damage to the RCHA during abdominal surgery has been associated with hemorrhage and ischemia. [11] In addition, the juxtaposition of portal venous structures in a RCHA makes identification of this artery imperative before performing a PD. [10] Vigilance is required since an RCHA coming off the SMA can travel in proximity to the pancreas in a number of ways. One of the more challenging presentations is when the RCHA is occurring throughout the body of the pancreas, also known as a trans-pancreatic common hepatic artery (tp-CHA). [12] Ishigami et al. (2018) assessed 788 consecutive liver transplant donor candidates who had undergone Multidetector-Row Computed Tomography (MDCT) studies to investigate vascular anatomy [12]. They found that the prevalence of the tp-CHA was ~ 0.38%; [12] however, one more recent case series assessed nine patients undergoing PD with a RCHA and found that the intrahepatic course occurred more often at a rate of 3 out of the 9 patients (33%). [13] Four of the patients had a posterior positioned artery, while in three cases, it was anteriorly located. In three of these patients, preoperative planning was performed with knowledge of the variation while in four cases, the CHA variation was not described in the preoperative radiology reports. A study by Ha et al in 2016 also looked at the course of the RCHA and found that up to 50% had an RCHA penetrating the pancreatic parenchyma. [14] The incongruence in the reported course of the RCHA among the studies suggests further large-scale analysis may be needed to better understand the vascular patterns of the RCHA when it arises. When the RCHA variation occurs, attempts to preserve the vessels are vital as these will help to maintain an adequate vascular supply and to prevent biliary damage and hepatic ischemia.

Conclusion

As our diagnostic methods and understanding of abdominal aortic branching variations improve, systematic algorithms and more centralized anatomical classification systems for treatment will likely help in the management of patients with less common vascular presentations. Since anatomical variations in branches of the CT are common, it is beneficial for clinicians and surgeons to identify the CHA course to pinpoint its origin prior to pancreatic surgeries. Surgical pre-planning that takes these variations into consideration is needed, as this will help with operative readiness, reduce complications, and help to improve patient outcomes.

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