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Quadrifurcation of the hepatic artery proper in conjunction with double right gastric arteries

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ABSTRACT Descriptions of the variant hepatic arterial pattern are common and frequently reported in anatomy archives. We describe a noteworthy deviation from the usual branching pattern in a single cadaver. There was a unique division of the hepatic artery proper into two right gastric arteries (RGAs), apart from the usual branches. Furthermore, an arterial loop was formed by these two RGAs, giving off another RGA, which we termed 'right gastric proper'. This report attempts to evaluate the embryological basis of the anomaly. The significance of this anomalous hepatic arterial pattern is appreciated while performing liver transplantations, hepatic artery infusion of chemotherapeutic drugs and Doppler angiographic procedures. We advocate meticulous familiarisation with the anatomy of the coeliac trunk and its topographic relationship to vital viscera for the operating hepatobiliary surgeon and radiologist.

Keywords: branching, duplication, hepatic artery, right gastric artery, variation
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INTRODUCTION

The coeliac trunk is a visceral branch of the abdominal aorta measuring 12.5 mm in length and 7–20 mm in thickness.[1] The coeliac trunk divides into the left gastric, common hepatic and splenic arteries. At the upper border of the first part of the duodenum, the common hepatic artery gives off the gastroduodenal artery and then continues as the hepatic artery proper (HAP). The right gastric artery (RGA) arises as a branch from the HAP. Subsequently, the HAP ascends in the right free margin of the lesser omentum, dividing into the right and left hepatic arteries in the vicinity of the porta hepatis.[2]

The unusual embryological development of the ventral splanchnic arteries could lead to a great deal of variations.[3] A previous study classified 1,000 hepatic arteries and consolidated them into six varieties.[4] The present case is unusual, as it involved duplication of the RGAs that stem from the HAP. Additionally, the cystic artery, the chief source of vascular supply to the gallbladder, was observed to stem from the HAP rather than the right hepatic artery, which is usually the case. The morphology of the abdominal aorta and its branches is relevant in the surgical and endovascular interventions of these vital vessels.[5]

Adequate knowledge of the possible arterial variations in relation to the coeliac trunk and its branches is mandatory for abdominal surgeons in order to avoid inadvertent injury to the vessels intraoperatively. Furthermore, with the inculcation of abdominal imaging as an important preoperative tool, familiarisation with this variant branching pattern assumes paramount relevance.

CASE REPORT

During a class for medical undergraduates, the dissection of the abdominal region of an adult Caucasian male cadaver revealed an abnormal branching pattern of the coeliac trunk. The common hepatic artery was of a wide calibre and measured 2.6 cm in length. It divided into the gastroduodenal artery and HAP. The HAP was 1.1 cm long and divided into the right and left hepatic arteries, and two RGAs. The two RGAs were designated as anterior (no. 3 in Fig. 1) and posterior RGAs (no. 4 in Fig. 1), and measured 2.1 cm and 3.1 cm in length, respectively. Distally, the two RGAs were observed to join, forming an arterial loop. An additional

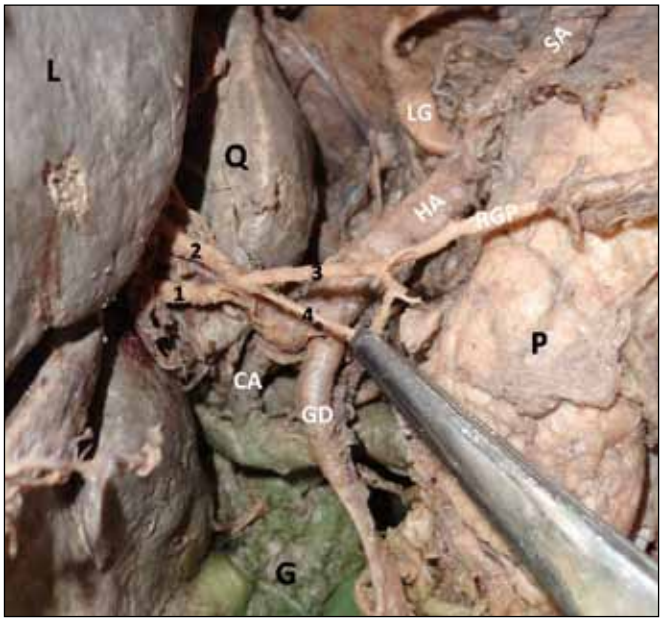

Fig. 1 Photograph shows the dissection of the right hypochondriac region.
G: gallbladder; L: liver; Q: quadrate lobe of the liver; P: pancreas; HA: hepatic artery; LG: left gastric artery; SA: splenic artery; GD: gastroduodenal artery; CA: cystic artery; RGP: right gastric proper; 1: right hepatic artery; 2: left hepatic artery; 3: anterior right gastric artery; 4: posterior right gastric artery

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artery emanated from this arterial loop, which we termed 'right gastric artery proper'. Therefore, an X-shaped arrangement of the branching pattern of HAP could be seen. The superior limbs of this cruciform arterial arrangement were formed by the two hepatic arteries, i.e. the right and left hepatic arteries, while the inferior limbs constituted of two RGAs that communicated distally to form an arterial loop. The cystic artery also arose from the HAP. The other two branches from the coeliac trunk were unremarkable and displayed a typical branching pattern. The liver also exhibited normal morphology.

DISCUSSION

To our knowledge, none of the earlier studies has reported a hepatic artery branching pattern that is similar to our case.[6,7] The atypical manner in which the double RGAs emanate from the HAP, as well as their subsequent union by the loop, is quite remarkable. In early embryos, four primitive splanchnic branches originating from the abdominal aorta are connected by a vertical longitudinal anastomosis termed as Lang's anastomosis. The gastric, common hepatic and splenic arteries develop from this longitudinal anastomosis. Persistence or disappearance of parts of this primitive arterial plexus is responsible for the various arterial variants of the coeliac trunk.[8]

As reported in a previous study, the common sites of abnormal origin of the RGA are the HAP (with an incidence of 40%–50%) and the right or left hepatic artery (with an incidence of 21%–42%).[9] A possible therapeutic approach for patients with unresectable advanced hepatic malignancies may be repeated hepatic artery infusion chemotherapy through an implanted port catheter system.[9,10] Owing to the anatomical variations associated with the RGA, it is cumbersome to selectively catheterise the RGA from the hepatic artery, which may result in the failure of embolisation of the vessel with coils. Anastomosis of the RGA with the left gastric artery (LGA) is normally observed. Therefore, introduction of the microcatheter through the LGA in order to negotiate the RGA is utilised by surgeons in these patients. This was a novel procedure tried out for the first time, where the LGA instead of the hepatic artery was used to advance the catheter into the RGA. A possible advantage of the above procedure is the protection of the RGA from chemotherapeutic agents used for hepatic artery embolisation. This prevents the occurrence of gastromucosal lesions, which normally results from the opening up of the RGA due to the leakage of chemotherapeutic agents into the gastric mucosal wall.

We opine that the presence of the unusual arterial loop connecting the two RGAs may have several clinical repercussions. First, the advancement of the catheter into the HAP may subsequently reach the RGA. Additionally, owing to the presence of two RGAs (the anterior and posterior RGAs), the dose of chemotherapeutic agents may have to be increased due to the increased length of the vessel. Another speculation is that the loop may facilitate the spread of chemotherapeutic drugs into the RGA and may therefore be effectively used for the same purpose. However, the success of this modality of treatment is halted by complications such as gastric or duodenal mucosal lesions resulting from the infusion of chemotherapeutic agents into neighbouring organs through the common hepatic artery, gastroduodenal artery and RGA. One way to prevent this complication is to embolise the arteries supplying these organs, and this requires one to be acquainted with the normal anatomy as well as the variations of the RGA. However, problems with embolising the RGA have been propounded due to the branching variants associated with it. In the current case, the presence of the two RGAs emanating from the HAP and having an unusual orientation with the right and left hepatic arteries may pose difficulties while attempting to embolise these vessels. The presence of the above anomaly warrants the introduction of a microcatheter for embolisation of the RGA into the HAP and through the arterial loop that was found to connect the two RGAs with the main RGA. It is the authors' supposition that the duplication of the RGA results in enhanced vascular supply to the gastric mucosa. Therefore, the dose of the embolising agent would have to be increased in order to effectively block the vessel prior to the introduction of the catheter. Hence, we suggest that the reporting of arterial variations be mandatory for the benefit of surgeons operating on this vital area.

Anomalies relating to the arteries of the abdomen can be detected by either an angiographic procedure or orthotopic hepatic transplantation, which permits a detailed analysis of the surgical anatomy of the liver. A previous study reported on the complications encountered while performing liver transplantations that accompany hepatic artery variations, such as microcirculatory failure and physiopathological changes related to ischaemia reperfusion injury.[11] All the abovementioned complications increase the chances of graft loss. In fact, hepatic artery reconstruction has been attempted by transplant surgeons. Therefore, the relevance of understanding the variant anatomy of this region cannot be undermined.

An acceptable alternative method is to determine the hepatic arterial pattern by cadaveric dissections, which may require thorough familiarisation of the variant arterial pattern. Hiatt et al studied the variations of hepatic arteries in 1,000 donor livers used for orthotopic transplantations and observed variant branching patterns of the hepatic arteries in 25%–75% of the cases.[4] These patterns were subsequently classified into six types in order of frequency. The present hepatic arterial pattern does not conform to the conventional branching pattern. To the best of our knowledge, the presence of the arterial loop between the two RGAs has not been documented in the literature. This report aims to enhance the anatomical knowledge of hepatic surgeons in order to prevent inadvertent intraoperative damage to the entire hepatobiliary apparatus along with the hepatic vasculature. In this era of laparoscopic surgery, variations in the origin and course of the cystic artery are of great relevance. The presence of such anomalous branching patterns of the HAP alters the laparoscopic appearance of the porta hepatis.[12,13] Owing to a restricted field of view in laparoscopic surgeries, exact and

precise knowledge of the arterial pattern of the porta hepatis is mandatory. Anomalies pertaining to the coeliac trunk, such as its quadrifurcation, pentafurcation and even hexafurcation, have also been described in a study.[14] In our case, a normal trifurcation was visualised, but thereafter, the branching of the common hepatic artery and HAP showed divergence from the usual pattern.

In view of these variations, surgeons and radiologists should keep a vigilant and observant approach while performing surgical interventions such as lymphadenectomy, aortic replacement or chemoembolisation of hepatic carcinomas.[15] Therefore, we advocate the nomenclature 'right gastric proper' for the artery that is formed by the joining of the posterior RGA to the anterior RGA. We also caution abdominal surgeons regarding the probable variations of the hepatic arterial pattern in order to avert intraoperative complications, which may prove to be devastating for the patient. It is thus the duty of gross anatomists to continually report such findings for the benefit of clinicians and surgeons.

In conclusion, the identification of these rare vascular variants is immensely relevant in contemporary surgical techniques involving transplantations. Timely recognition of this branching pattern may help surgeons avoid injury during operation. Every attempt should be made to carefully dissect and note arterial variations for the benefit of both hepatic and gastric surgeons.

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