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Original Article

A STUDY OF VARIANT HEPATIC ARTERIAL ANATOMY AND ITS RELEVANCE IN CURRENT SURGICAL PRACTICE

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ABSTRACT

Background: With increase in the number of laparoscopic procedures, oncologic surgical interventions and organ transplant cases, anatomy and variations of hepatic arterial system have become increasingly important. Variations in these vessels may predispose the patients to inadvertent injury during open surgical procedures or percutaneous interventions.

Aims: The present study is intended to contribute to the pre-existing data regarding the variations in the branching pattern of hepatic artery and throw light on their clinical implications.

Methods: Extrahepatic branching pattern of hepatic arteries were studied in 40 embalmed cadavers of both sexes by dissection method.

Results: Classical text book pattern of hepatic arterial anatomy was seen in 30(75%) cases and ten (25%) cases showed the presence of aberrant hepatic arteries. 12 aberrant hepatic arteries were seen in these ten cases, eight (20%) cases with single aberrant hepatic artery and two (5%) with combination of aberrant right and left hepatics. Aberrant right hepatic arteries were seen in four (10%) cases and all of them were replaced right hepatics arising directly from celiac trunk. Aberrant left hepatic arteries were seen in eight (20%) cases, of which six (15%) were accessory, two (5%) were replaced and all of them arose from the left gastric artery.

Conclusion: Because of high incidence of variations in branching pattern of hepatic artery it is very important to have a thorough knowledge of these variants and identify them so as to prevent iatrogenic injuries and increase rate of success of the surgical and interventional procedures in hepatobiliary region.

KEY WORDS: Aberrant Hepatic Artery, Accessory Hepatic Artery, Replaced Hepatic Artery, Liver Transplantation, Hepatic Arterial Infusion Chemotherapy.

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INTRODUCTION

An intact hepatic artery is the gateway to successful hepatobiliary surgery. Division or damage with subsequent thrombosis produces ischemia of liver or bile duct which can have devastating consequences on the patient. The promotion of the knowledge of hepatic vascular distribution and its variations is fundamental to plan and to make all surgical and radiological procedures in upper abdomen [1]. Because of the advent of interventional and surgical techniques to treat both primary and metastatic liver tumors and the increasing availability of living related liver transplant donors, the depiction and definition of the hepatic arterial anatomy has become crucial [2].

Terminologies: A typical 'normal' hepatic artery arises from celiac trunk and divides into three main branches- the right hepatic, left hepatic and middle hepatic supplying the right, left and quadrate lobe of the liver respectively. 'Aberrant' hepatic is a hepatic arising otherwise than from a typical celiacal hepatic and is of two types- accessory and replaced. The term 'accessory' hepatics should be used only in those cases where the normal celiacal right or left hepatic is present and there is an additional artery from other sources. When the normal celiacal right or left hepatic artery is missing the replacing vessel coming from another source supplying the right or left lobe is to be termed as a 'replaced' right or left hepatic artery [3].

This study is aimed to study the variations in extrahepatic branching pattern of hepatic artery and to emphasize the importance of identifying the variations of hepatic artery, the knowledge of which is very essential to practice safe hepatobiliary surgery.

MATERIALS AND METHODS

Present study was carried out in 40 embalmed cadavers of both sexes allotted to undergraduate students in the Department of Anatomy at Bangalore Medical College and Research Institute, Bangalore and Shimoga Institute of Medical Sciences, Shimoga from 2008-2013. Abdomen was opened following the Cunningham's manual and liver was pulled superiorly to expose the lesser omentum. Hepatic artery and its branches were cleared and traced from their origin up to the porta hepatis. The origin, course, and extrahepatic branching pattern of hepatic artery were studied and percentage of their variations calculated.

RESULTS

Out of the 40 cadavers studied, text book description of common hepatic artery originating from celiac trunk and dividing into right and left hepatic artery (sometimes middle hepatic artery also) was seen in 30(75%) cases [Figure 1]. The common hepatic artery of celiac origin passed forwards and to the right along the upper border of head of the pancreas in a fold of posterior parietal peritoneum. It then turned upwards and forwards behind the superior part of duodenum into the hepatoduodenal ligament. At the lower end of epiploic foramen, it gave off the gastroduodenal artery and became hepatic artery proper which turned forwards and upwards between the two layers of lesser omentum in front of the epiploic foramen towards the porta hepatis where it divided into right and left hepatic branches to the corresponding lobes of the liver. The left hepatic artery crossed the caudate process of liver to reach the left lobe. Right hepatic artery crossed the common hepatic duct dorsally in 21 cases, ventrally in nine cases, and in six cases it ascended to the left of the common hepatic duct before entering the right lobe of liver. Middle hepatic artery supplying the quadrate lobe of the liver was given extrahepatically in 14(35%) cases and was found arising from the right hepatic artery in six (15%), left hepatic artery in four (10%) and hepatic artery proper in four (10%) cases. Trifurcation of common hepatic artery into gastroduodenal, right and left hepatic arteries was seen in seven (17.5%) cases [Figure 2]. Hepatic artery proper was absent in these cases.

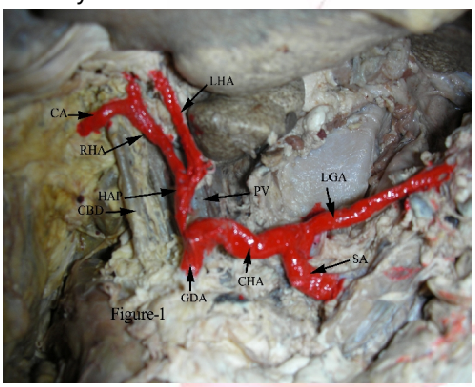
Aberrant hepatic arteries were found in ten (25%) cases [Figure 2-5]. Twelve aberrant hepatic arteries were seen in ten cadavers, of which eight (20%) showed the presence of single aberrant hepatic artery, aberrant left hepatic in six (15%) cases and aberrant right hepatic in two (5%) cases. Two (5%) cases showed a combination of aberrant right and left hepatic arteries.

In all, aberrant right hepatic arteries were seen in four (10%) cases and all of them were replaced right hepatics arising directly from the celiac trunk [Figure 3,4]. All the aberrant right hepatics ascended dorsal to the portal vein and then the common hepatic duct to enter into the Calot's triangle before entering the right lobe of the liver.

Aberrant left hepatic arteries were seen in eight (20%) cases. All of them arose from the left gastric artery of which six (15%) were accessory (Figure 2) and two (5%) were replaced (Figure 5). After origin from the left gastric artery, the aberrant left hepatic arteries ascended upwards near the esophagus between the layers of lesser omentum, crossed the caudate lobe and entered

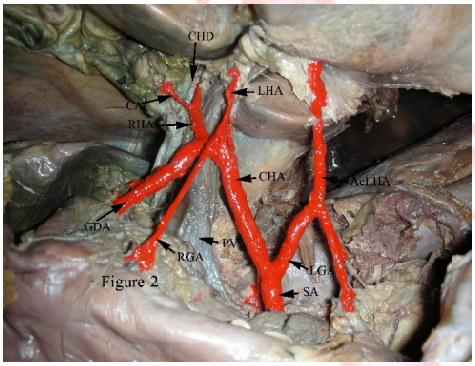
the liver through the fissure for ligamentum venosum. In their upward course along the peripheral edge of the lesser omentum, they gave off one-two accessory left gastric branches to the lower end of esophagus and upper end of stomach in three (7.5%) cases.

Fig. 1: Showing normal origin and branching pattern of hepatic artery.



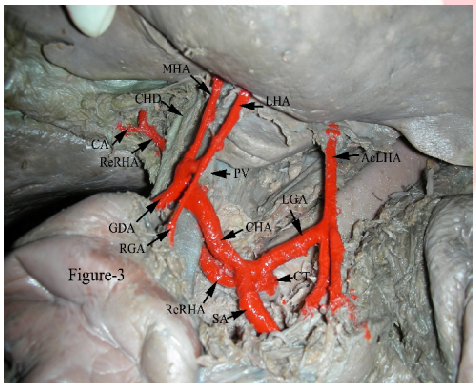
(LGA- Left gastric artery, SA- Splenic artery, CHA- Common hepatic artery, HAP- Hepatic artery proper, RHA- Right hepatic artery, LHA- Left hepatic artery, CA- Cystic artery, GDA- Gastroduodenal Artery, PV- Portal vein, CBD- Common Bile Duct)

Fig. 2: Showing accessory left hepatic artery arising from left gastric artery and trifurcation of common hepatic artery.



(AcLHA- Accessory left hepatic artery, RGA- Right gastric artery, CHD- Common hepatic duct)

Fig. 3: Showing combination of replaced right hepatic from celiac trunk and accessory left hepatic from left gastric artery.



(CT- Celiac trunk, MHA-Middle hepatic artery, ReRHA-Replaced right hepatic artery)

Fig. 4: Showing replaced right hepatic artery from celiac trunk.

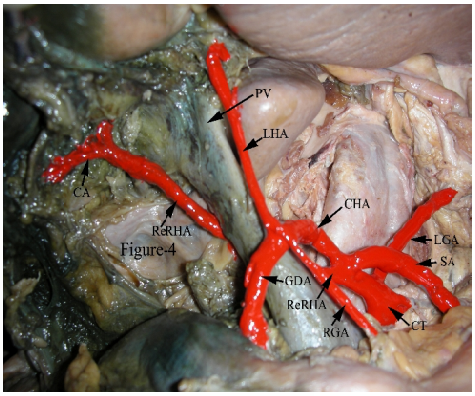
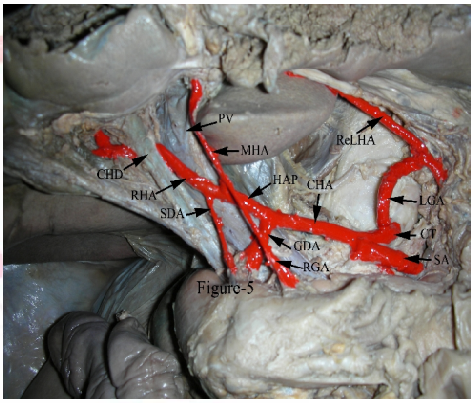


Fig. 5: Showing replaced left hepatic from left gastric artery.



(ReLHA- Replaced left hepatic artery, SDA- Supraduodenal artery)

DISCUSSION

The incidence of classical text book description of liver receiving its blood supply solely from right and left branch of celiacal hepatic artery observed in other studies ranged from 34.5-75.7% [2,3,4,5]. In present study this was seen in 30(75%) cases. Termination of common hepatic artery by trifurcating into right hepatic, left hepatic and gastroduodenal artery is considered as normal and is found in 1.5-8.3% cases [2,6]. In present study, trifurcation was seen in seven (17.5%) cases which was higher than the previous studies.

Anatomical variations in arterial supply of liver are reported to occur in 25-50% of the population [2,3,7] whereas in our study, aberrant hepatic arteries were seen in ten (25%) cases. Variations in the origin of common hepatic are rare and may be seen arising from left gastric, superior mesenteric or abdominal aorta [2,3,7]. The incidence of these variants is 0.5%- 4.5% [3,5,8]. However in present study such variations were not observed.

The incidence of aberrant right hepatics as reported in other studies is 11-26% [2,3,4,9]. In present study, these variants were seen in four (10%) cases and all of them were replaced right hepatics. In other studies replaced right hepatic arteries were seen 3.5-21% of cases and accessory right hepatic arteries in 1-8% cases [3,4,10]. It is evident from these findings that percentage of replaced artery as sole supply to right lobe of liver is more than that of accessory artery supplying the right lobe. The aberrant right hepatics may arise from superior mesenteric artery, gastroduodenal, retroduodenal, aorta, left gastric or may arise independent of the left hepatic from the celiac trunk [2,3]. In our study all the aberrant right hepatics arose directly from the celiac trunk.

The incidence of aberrant left hepatics as observed in other studies is 12.5-32% [3,4,10]. In the present study, aberrant left hepatic arteries were seen in eight (20%) cases. In other studies, accessory left hepatic arteries were seen in 4.5-32% cases and replaced left hepatic arteries in 4-15.5% cases [3,4,10,11]. In the present study, accessory left hepatics were seen in six (15%) cases and replaced left hepatics in two (5%) of cases, all arising from left gastric artery. Another study on variant hepatics showed similar results with all aberrant left hepatics arising from left gastric artery [4]. Origin from other sources like celiac trunk, aorta, splenic, right gastric, gastroduodenal and superior mesenteric artery, right hepatic as seen in other studies [3,7,10] were not seen in the present study.

These aberrant arteries can be attributed to abnormal persistence or regression of embryonic arteries. In early human embryos (4-17mm) the omphalomesenteric artery (superior mesenteric artery) arises by four roots (10th, 11th, 12th and 13th ventral segmentals) which are united by ventral longitudinal anastomosis running parallel to the aorta. Normally greater part of this ventral longitudinal anastomosis disappears as do the two middle roots (11th and 12th) leaving the first root to become stem of celiac and last root to become stem of superior mesenteric artery. The ventral longitudinal anastomosis between the roots of primitive vitelline arteries is the common source of origin of all the branches of celiac artery and of accessory hepatic arteries, persistence of interrupted sections accounting for aberrancy in origin of regional arteries [3].

Surgical importance: Anatomical knowledge of variants of hepatic artery is required to reduce the iatrogenic complications in hepatobiliary surgeries, surgical management of liver trauma, aneurysm of hepatic artery, hepatic arterial infusion chemotheraphy, liver transplant surgery, pancreaticoduodenectomy, radical gastrectomy and such other surgeries of this complex anatomical region [12]. These variants are relevant in cholecystectomy because they affect the laparoscopic appearance of porta hepatis [5,12].

In liver transplants appropriate evaluation of hepatic arteries is essential for reducing operative and postoperative morbidity and mortality in both donors and recipients. Presence of anatomical variation of hepatic artery in the donor requires an adaptation of arterial reconstruction technique to obtain an optimum perfusion of territories of the graft and avoid complications like thrombosis of the hepatic artery [12]. Replaced right hepatic artery is a beneficial variant in right liver living donors. The common postoperative complication in liver transplantation is hepatic artery thrombosis because of shorter and thinner hepatic artery graft. But replaced right hepatic artery in right lobe liver 'donor' provides a longer and larger graft thus reducing chances of hepatic artery thrombosis in them [7,13,14]. Replaced right hepatic artery in liver transplant 'recipient' increases risk of hepatic artery complications after transplantation due to small calibre of common hepatic artery [13]. Accessory hepatic arteries are a challenge in liver transplantation since multiple vascular anastomosis have to be performed between donor and recipient vessels. If accessory vessels are not anastomosed properly it may lead to several postoperative complications such as necrosis of liver parenchyma, acute liver failure, hepatic arterial insufficiency, hepatic arterial thrombosis and stenosis and other fatal complications which increase the mortality and morbidity [15].

Diagnostic and interventional radiologists should be familiar with the cross sectional and 3D appearance of variations in celiac axis and

hepatic artery anatomy. Preprocedural CT evaluation of these vessels can help one perform and interpret the findings of diagnostic angiography for intra-arterial management of hepatic tumors and perform embolotherapy for haemorrhage [12]. Varied branching pattern can make hepatic arterial infusion chemotherapy and microcatheter embolization techniques difficult and can result in incomplete embolization of liver tumors [2,16]. Presence of an aberrant vessel can result in improper catheter tip placement causing damage to normal liver parenchyma during chemoembolization or hepatic arterial infusion chemotherapy [17]. Thorough knowledge of variant hepatic artery is fundamental to angiographic practice, in particular for interventional procedures, because such variants can influence the choice of vascular techniques and of materials [18].

Aberrant right hepatic artery from superior mesenteric artery or aorta courses in relation to the head of the pancreas and is susceptible to intraoperative damage during pancreaticoduodenectomy and pancreatic tumors. It may have unusual relations in right free border of lesser omentum and present hazards while performing cholecystectomy [19]. If the aberrant right hepatic arises from left gastric it presents an additional risk of injury during mobilization of stomach [20]. Presence of aberrant right hepatic leads not only to alteration in the surgical approach but may also adversely affect the outcomes of surgical procedure [12,21]. Injury to right hepatic artery leads to intra or postoperative bleeding and ischemia of right lobe of liver. The extrahepatic biliary tree receives a substantial portion of its blood supply from right hepatic artery and injury will lead to ischemia of the biliary anastomosis, resulting in a biliary anastomotic leak [21]. Compression of common hepatic duct by aberrant right hepatic artery could lead to bile stasis and bacterial proliferation ending in gallstone formation [22]. Presence of tortuous right hepatic artery (caterpillar hump) may lead to vascular injuries during surgical procedures in this region as such an artery is closer to the cystic duct and the cystic artery is short. It is important for surgeons to know this variant to avoid inadvertent ligation of right hepatic artery instead of cystic artery, thereby preventing vascular injuries and the fatal ischaemic necrosis of right lobe of the liver [23].

An aberrant left hepatic artery is a variation to be looked for during liver transplantation, gastric surgeries, hiatal surgery for gastroesophageal reflux and bariatric surgery because it lies in the hepatogastric ligament and is prone for laceration or ligation causing fatal ischemic necrosis of left lobe of the liver [3,24]. However accessory left hepatic artery may also be advantageous in some instances. Due to the proximity of the right hepatic artery to the bile duct, bile duct cancer usually spreads to the right hepatic artery but the further distance between accessory hepatic artery and bile duct implies that these vessels will be spared in cancers of bile duct. Also, aberrant left hepatics provide collateral circulation in case of occlusion of the vessels in the porta hepatis [25]. Accessory left gastric artery arising from the normal or aberrant left hepatic artery is an important variant to be recognized as it affects both the diagnosis and treatment of distal esophageal and proximal gastric haemorrhage and also in intraarterial infusion of chemotherapeutic agents for hepatic neoplasms [26]. A case of hepatocellular carcinoma developing gastric perforation after transarterial embolization is reported due to necrosis of gastric wall following obliteration of accessory left gastric artery [27].

Variant arterial anatomy recognized during cadaveric dissection offers great learning potential and provides alternative perspective to view common morphology with its structural and functional importance. These impart the concept of patient individuality and subsequent individualization of medical and surgical therapies [28].

CONCLUSION

It is evident from this study that variations in the arterial supply of liver are very common. The relations of hepatic artery and its branches to the portal vein and biliary tract also showed variations which if not recognized during surgical exploration can lead to fatal complications like haemorrhage and biliary fistula. Hence it can be concluded that surgeons should be well equipped with the knowledge of detailed arterial

anatomy of the hepatobiliary region before attempting any surgical intervention in this region to prevent fatal intra and postoperative complications.

ABBREVIATIONS

CT- Celiac Trunk
LGA- Left Gastric Artery
SA- Splenic Artery
CHA- Common Hepatic Artery
HAP- Right Hepatic Artery
RHA- Left Hepatic Artery
MHA- Middle Hepatic Artery
Ac LHA- Accessory Left Hepatic Artery
Re RHR- Replaced Right Hepatic Artery
Re LHA- Replaced Left Hepatic Artery
GDA- Gastroduodenal Artery
CA- Cystic Artery
RGA- Right Gastric Artery
SDA- Supraduodenal Artery
PV- Portal Vein
CBD- Common Bile Duct
CHD- Common Hepatic Duct

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Conflicts of Interests: None

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