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**Accessory right hepatic artery and aberrant bile duct in the hepatocystic triangle:
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Abstract

Awareness of variations in the hepatic vasculature and biliary system is extremely important for avoiding iatrogenic injury in upper-abdominal surgery. The objective of this study is to describe a rare case of abnormal vascular and biliary structures in the hepatocystic triangle (HCT) (the modern Calot's triangle). During anatomical dissection of the celiac trunk (CT) in an old man, the authors observed the presence of a hepatosplenic trunk arising from the CT and bifurcating into common hepatic and splenic arteries. The common hepatic artery divided into hepatic artery proper and gastroduodenal artery. The presence of accessory right hepatic artery (ARHA) arising

from the superior mesenteric artery was also notable. The aberrant artery ascended retropancreatically ventral to the splenic vein, then posterolaterally to the portal vein before termination into the right hepatic lobe in the HCT. Within this triangle, there was an aberrant bile duct originating in the right hepatic lobe and ending in the common hepatic duct. This accessory duct crossed the ARHA and an associated branch (the cystic artery). There is no known previous report on the co-existence of an AHAR and an aberrant bile duct within the HCT, in addition to the hepatosplenic trunk. The clinical implications of the current case are addressed in discussion.

Key words: hepatocystic triangle, triangle of Calot, accessory right hepatic artery, aberrant bile duct, hepatosplenic trunk, variations, celiac trunk

INTRODUCTION

Variations in blood supply to the hepatic arteries are not rare. According to anatomy text books, the common hepatic branch of the celiac trunk (CT) supplies the liver in 55-88% of cases. Variations of liver blood supply are frequent. Thus, the liver may be supplied by aberrant branches of the left gastric artery, the superior mesenteric artery (SMA), the aorta or other gut arteries. These aberrant arteries may be accessory or replaced [5, 6, 9, 22].

Recognition of variations in hepatic arterial anatomy is of major importance in the planning and conducting of surgical and radiological procedures on the upper-abdomen area, such as transplantation, cholecystectomy and pancreaticoduodenectomy [6, 8, 9, 22]. Based on records of 1000 patients who underwent liver harvesting for orthotopic transplantation, Hiatt et al. [9] investigated the surgical anatomy of hepatic arteries. They found six types of hepatic artery variations. Type 1-normal (the common hepatic artery (CHA) branched from celiac trunk) (75.7 %); type 2-replaced (accessory) left hepatic artery branched from left gastric (9.7%); type 3-replaced (accessory) right hepatic artery branched from SMA (10.6%); type 4- replaced or accessory right hepatic

artery +replaced or accessory left hepatic artery (2.3%); type 5- the CHA branched from SMA (1.5%) and type 6-the CHA originated from abdominal aorta (0.2%). The presence of an aberrant right hepatic artery is the most frequently encountered variation, and this may be either a replacement or an accessory (Hiatt Type III, 10.6% incidence) [5, 9]. This aberrant artery may be accidentally injured during upper-abdomen operations resulting in fatal complications such as severe hemorrhage and hepatic necrosis [5, 6, 9, 22]. Importantly, biliary tract variations – specifically, the presence of aberrant or accessory bile ducts – may complicate laparoscopic cholecystectomy. During this procedure, only two structures (the cystic duct and the cystic artery) should usually be seen entering the gallbladder within the hepatocystic triangle (HCT) (the modern Calot’s triangle), which is bounded by the cystic duct, the common hepatic duct (CHD) and the liver. This is different from the earlier description of Calot: the Calot’s triangle is demarcated by the cystic duct on right side, the CHD on left side, and the cystic artery above [1, 16, 17]. In a previous study, the authors reported a rare case of a right hepatic artery forming a caterpillar hump perforating Calot's triangle into the cystic plate in association with a variant branching pattern of the CT [7]. In the current study, the authors referenced cadaveric dissection results to examine another rare case involving the coexistence of three variations with clinically important implications in hepatobiliary and pancreatic surgery. These variations include two structures (an accessory right hepatic artery (ARHA) and an aberrant bile duct) within the HCT, in addition to the hepatosplenic trunk.

CASE REPORT

During anatomical dissection of the CT in a male cadaver (among eight dissections) at the Department of Anatomy in the College of Medicine and Health Sciences at the United Arab Emirates University, multiple variations in hepatic vasculature and the biliary system were observed. The CT was exposed after severing the greater omentum and upward reflection of stomach. The CT bifurcated into the left gastric artery and hepatosplenic trunk (Fig. 1). The hepatosplenic trunk divided into CHA and splenic artery. The CHA then branched into gastroduodenal artery and hepatic

artery proper (HAP), which trifurcated into right, left and middle hepatic branches (Fig. 2). This trifurcation of HAP was observed after dissection of the hepatoduodenal ligament. Further dissection of the pancreatic bed demonstrated the presence of an ARHA arising from the SMA. The ARHA ascended retropancreatically ventral to the splenic vein at its junction with the superior mesenteric vein parallel to the common hepatic artery (Fig. 1). Notably, it passed posterolaterally to the portal vein and the CHD, entering the HCT and terminating into the right hepatic lobe close to the cystic plate. In this triangle, the ARHA gave rise to the cystic artery, and both arteries were crossed ventrally by an aberrant bile duct arising from the right hepatic lobe and joining the right side of the CHD (Fig. 2). The gallbladder was dissected from the cystic plate via upward retraction and severing of its peritoneal attachment, thereby clearly revealing the contents of HCT – the ARHA, the aberrant bile duct and the cystic artery based on the criteria of Critical View of Safety (CVS) for laparoscopic cholecystectomy by Strasberg [16,17] (Fig. 3). The CVS has 3 requirements. First, the HCT must be cleared of fat and fibrous tissue. The second requirement is that the inferior part of the gallbladder be separated from the cystic plate (hepatic bed of gallbladder), the flat fibrous surface to which the non-peritonealized side of the gallbladder is attached. The third requirement is that only 2 structures (cystic duct and cystic artery), must be seen getting into the gallbladder. Once these 3 criteria have been fulfilled, CVS has been attained. The normal and variant anatomy of HCT is shown in Fig. 4 with digital art based on schema of Fig. 2

DISCUSSION

In the case reported here, the ARHA and the anomalous bile duct were observed simultaneously as variant structures in the HCT, along with a variant branching pattern of the CT with formation of the hepatosplenic trunk. Up to our knowledge, there are no known previous reports on the coexistence of these variations.

The detection of an ARHA arising from the SMA in the current case is consistent with Hiatt Type III (10.6% incidence) [5, 9]. This artery ascended superficial

to the splenic vein and deep to the pancreatic neck. Accordingly, there may have been compression of the splenic vein by the enlarged ARHA and the pancreas, resulting in splenic vein thrombosis and left-sided portal hypertension [19]. In addition, the entry of the ARHA into the HCT has great surgical relevance, as injury may occur during laparoscopic cholecystectomy with catastrophic complications such as bleeding and liver ischemia [6, 16, 17, 22]. The ARHA may also be damaged in various procedures associated with tumor-related pancreaticoduodenectomy [8]. Developmentally, the presence of ARHA may result from persistence and/or abnormal regression of the embryonic hepatic arteries [5].

The presence of an ARHA within the HCT has been reported in a couple of studies [6, 12, 15], but was here associated with the aberrant bile duct, which may complicate CVS during laparoscopic cholecystectomy [16,17]. On the other side, some studies have shown that the replaced right hepatic artery is a beneficial variant in the right hepatic lobe living donors transplant. This could be explained by the fact that the shorter hepatic artery graft could lead to a postoperative complication (hepatic artery thrombosis). However, the replaced right liver artery in such cases provides a longer and bigger graft, thereby reducing the chances of hepatic thrombosis. This could be applicable to our case as ARHA seems to be longer than the HAP [22]. Recent studies investigated the presence of ARHA using CT, MDCT angiography and MRI. An enhanced CT scan revealed variations in hepatic arteries in a 67-year-old woman diagnosed with intrahepatic cholangiocarcinoma [11]. These variations included ARHA branching from SMA and an accessory left hepatic artery arising from the left gastric artery. Using CT angiography or/and MRI angiography findings in 532 patients, Yamaguchi et al. [21] observed a case of aberrant right hepatic artery arising from the gastroduodenal artery. They recommended the use of preoperative CT and/or MRI and intraoperative liver Doppler ultrasound for the prevention of injury during pancreaticoduodenectomy in patients with this type of hepatic artery variation. Some researchers believe that ultrasound is always the method of choice for the diagnosis of various hepatobiliary diseases. They recommend a perfect study and a good understanding of the sonographic appearance of the normal hepatic vascular tree and its anatomical variations [3].

Importantly, the laparoscopic cholecystectomy CVS requirements [16,17] applied during HCT dissection in the current study can also be used for practical anatomy teaching in medical schools. This may encourage undergraduate and postgraduate students to perform research on anatomical variations with clinical relevance.

Accidental injury or ligation of an aberrant bile duct as observed in the present case during cholecystectomy may result in severe complications such as biliary leakage and biliary cirrhosis [10,13,16-18]. However, some researchers consider any bile duct activity from the right lobe of the liver and interaction with the CHD as aberrant. Therefore, the lack of interductal communication in the liver may indicate that this duct may be the sole drainage of this particular part of the liver. When such an aberrant duct enters the main duct near the cystic duct, it may be easily injured, resulting in partial or total segmental duct occlusion. These ducts have a relatively high prevalence (8.4 per cent) and should be investigated using intraoperative cholangiography [10]. As shown in Fig.4, the cystic artery in our case is bridged by the aberrant bile duct, therefore, there is great possibility of injury of the duct during cholecystectomy. A recent study for the first time reported that fluorescence cholangiography concomitant with angiography was useful for identifying an aberrant bile duct and the cystic artery during laparoscopic cholecystectomy in old patient. The authors concluded that abnormal bile ducts are clinically important due to higher sensitivity to lesions during cholecystectomy. About 27% of clinically significant bile duct leakage was reported to be due to an aberrant bile duct lesion [18].

A recent report highlighted the coexistence of an ARHA and a left hepatic artery originating directly from the CT in a patient who had undergone an elective pancreaticoduodenectomy via the Whipple procedure [2]. In the current case, in addition to the ARHA, the authors observed the presence of a hepatosplenic trunk arising from the CT. The presence of this trunk was reported as a type-II CT based on Adachi classification (4.3%) [5]. Recent studies also found that a hepatosplenic trunk is observed in 10% of cases based on cadaveric dissection [14] and in 3.88% of subjects based on multidetector computed tomography [20]. The authors concluded that this CT

variation was relevant to the planning of radiological and surgical procedures on the abdominal part of the esophagus, the stomach, the duodenum, the liver, the pancreas, the gallbladder and the spleen, and in operations such as liver transplantation.

CONCLUSIONS

This unique study on the simultaneous presence of an ARHA, aberrant bile duct and a hepatosplenic trunk has important surgical implications; specifically, in hepatobiliary surgery. Further research on large number of cases using cadaveric dissection and imaging tools such as ultrasound, MRI and CT are required to explore the abnormal contents of HCT.

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List of Abbreviations: HCT: hepatocystic triangle; CT: celiac trunk; ARHA: accessory right hepatic artery; SMA: superior mesenteric artery; CHD: common hepatic duct; CHA: common hepatic artery; HAP: hepatic artery proper; CVS: critical View of Safety; ST: stomach; P: pancreas; SMV: superior mesenteric vein; SV: splenic vein; LRV: left renal vein; LGA: left gastric artery; HST: hepatosplenic trunk; SA: splenic artery; AA: abdominal aorta; LIPA: left inferior phrenic artery; GDA: gastroduodenal artery; PV: portal vein; CBD: common bile duct; CD: cystic duct; IV: Hepatic segment 4; CP: cystic plate; GB: gallbladder; ABD: aberrant bile duct.

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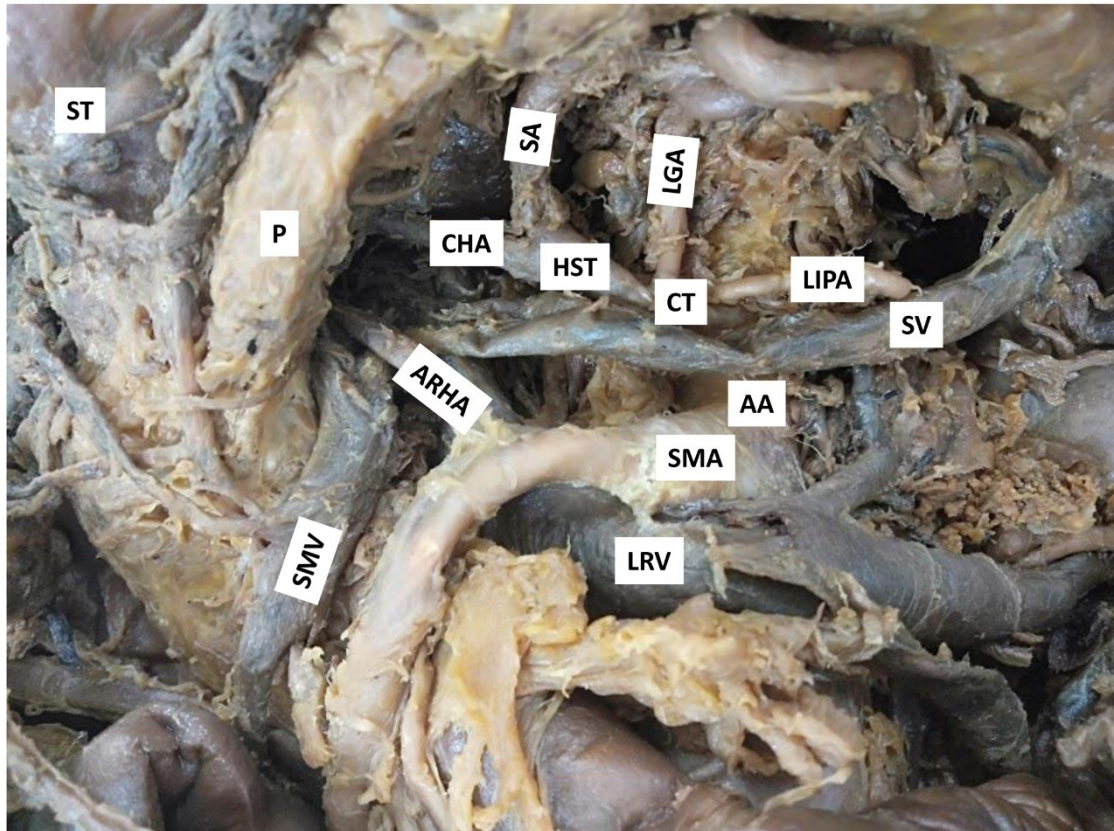


Figure 1. Accessory right hepatic artery (ARHA) arising from the superior mesenteric artery (SMA) in the pancreatic bed. The stomach (ST) and pancreas (P) are retracted to show the variation. SMA: superior mesenteric artery; SMV: superior mesenteric vein; SV: splenic vein; LRV: left renal vein; CT: celiac trunk; LGA: left gastric artery; HST: hepatosplenic trunk; SA: splenic artery; CHA: common hepatic artery; AA: abdominal aorta; LIPA: left inferior phrenic artery.

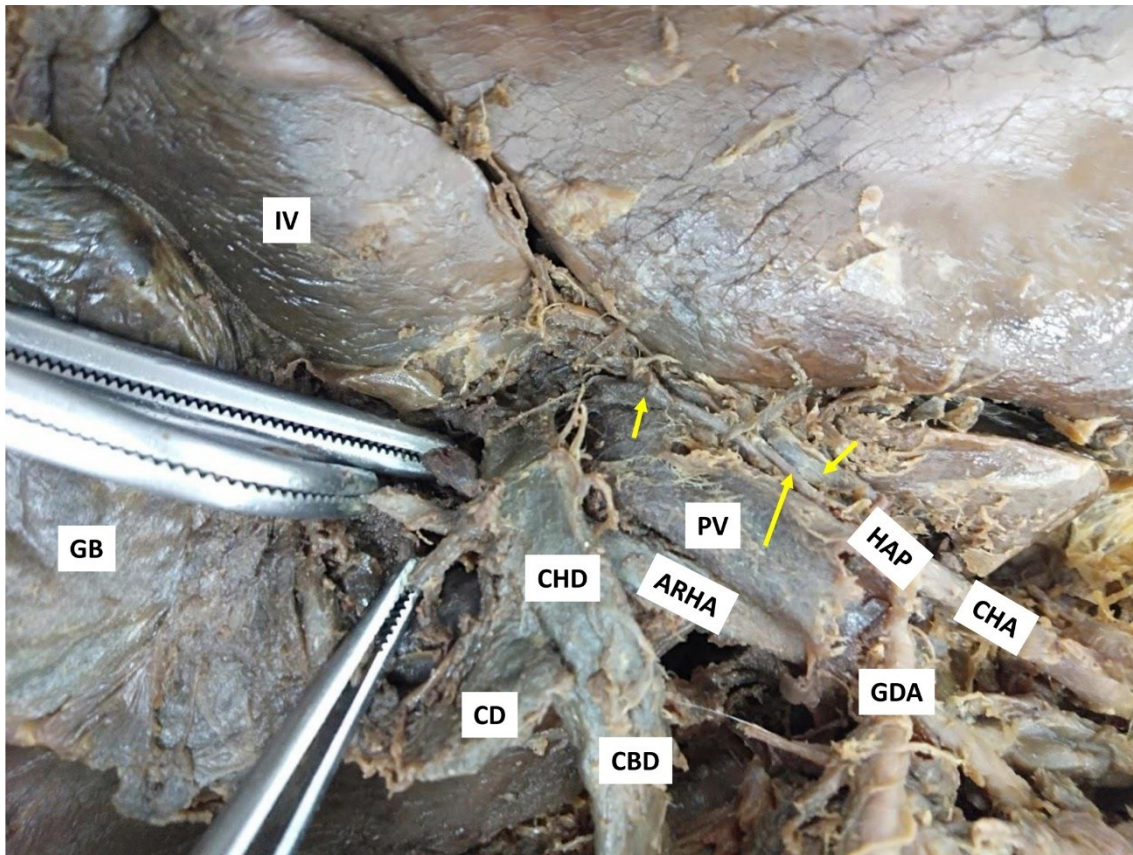


Figure 2 ARHA passing into the HCT in association with the accessory bile duct and cystic artery. The upper, middle and lower haemostats within the triangle hold the ARHA, cystic artery and anomalous bile duct, respectively. The yellow arrows mark the right, left and middle hepatic branches of the hepatic artery proper (HAP). CHA: common hepatic artery; GDA: gastroduodenal artery; PV: portal vein; CHD: common hepatic duct; CBD: common bile duct; CD: cystic duct; IV: hepatic segment 4.

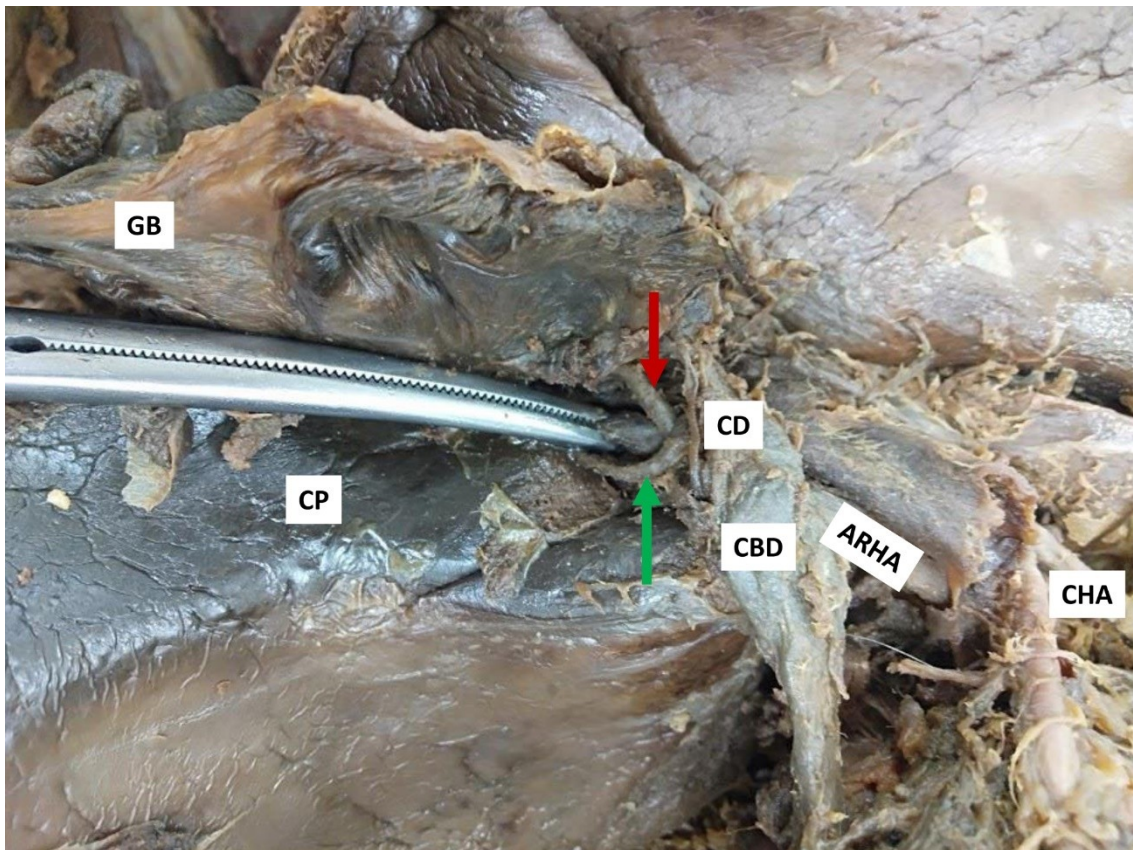


Figure 3. Dissection and upward retraction of gall bladder (GB) for exposure of cystic plate and detection of anomalous structures in the hepatocystic triangle based on criteria of CVS. Note that the ARHA is grasped by the haemostat, whereas the cystic artery and aberrant bile duct are marked by the red and green arrows, respectively. CP: cystic plate; CBD: common bile duct; CD: cystic duct; ARHA: accessory right hepatic artery; CHA: common hepatic artery.

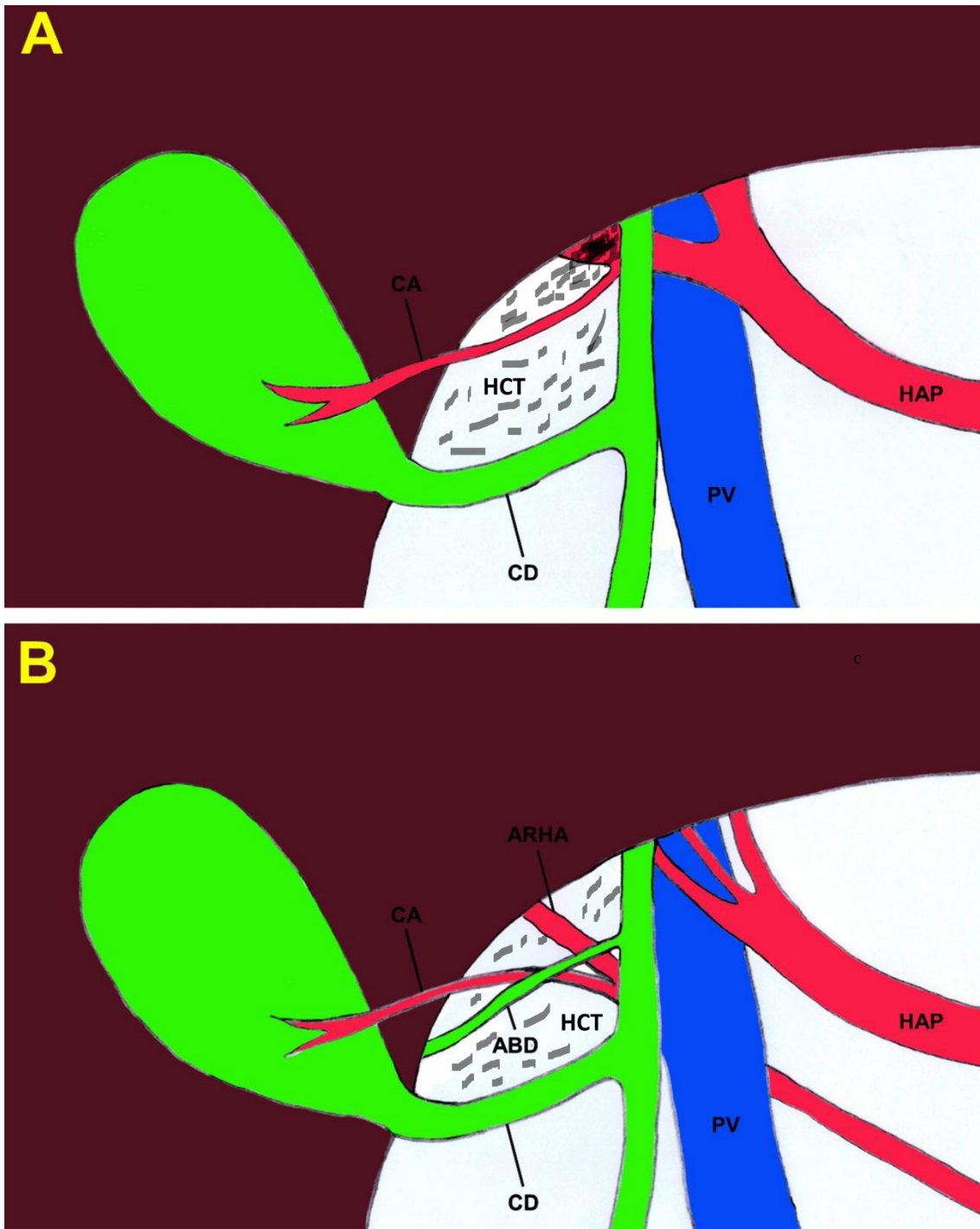


Figure 4. A schema and digital art (A, B) showing the normal (A) and variant anatomy of the HCT (highlighted with black lines) of Calot (B). The digital art of B is based on figure 2. PV: portal vein; CHD: common hepatic duct; CBD: common bile duct; CD: cystic duct; ARHA: accessory right hepatic artery; HAP: hepatic artery proper; GB: gallbladder; ABD: aberrant bile duct.