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A Monograph on Anatomy and Variants of Hepatic Resectional Surgery

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Abstract

BACKGROUND: The liver anatomy appears to be very complex due to the enormous number of vascular and biliary branches as well as the fact that the underlying pathology frequently distorts the anatomy. To prevent damage during surgical or invasive procedures, it is advised to be aware of the arteries' typical structure and variations. Hepatic surgeons, general surgeons, transplant surgeons, interventional radiologists, and other medical specialists who treat liver problems must have this knowledge.

MATERIALS AND METHODS: We have retrospectively evaluated the PubMed databases, Embase, and the Cochrane Library by applying various combinations of subject-related terms. The search terms identified with the medical subject heading were "Anatomy, right hepatectomy, resection, variants." The databases were used to collect the literature published since 1991.

RESULTS: Results delineated that 91.6% of patients had a single right hepatic vein, 81% shared a trunk with their middle hepatic vein (MHV) and left hepatic vein (LHV), and 19% had separate MHV and LHV drainage into the inferior vena cava. Overall prevalences of the abnormal hepatic artery, abnormal right hepatic artery (aRHA), abnormal left hepatic artery (aLHA), and combined aRHA/aLHA were found to be 27.41%, 15.63%, 16.32%, and 4.53%, respectively. The most common variation (type 2) is the so-called "portal vein (PV) trifurcation," in which the main PV divides into the left PV, the right anterior PV, and the right posterior PV. The right posterior sectoral duct joins the left hepatic duct with a supraportal course, the right posterior sectoral duct joins the right anterior sectoral duct with an infraportal course, the trifurcation variation of the biliary tree, retroportal course, and the left lateral segmental ducts caudal to the umbilical portion of the PV are examples of variant biliary anatomy encountered in PV variations. Duplication of the common bile duct is a very uncommon congenital biliary system defect.

CONCLUSION: It is very crucial for surgeon to have abreast knowledge of the tributaries, their anatomy, and variations to limit blood loss and operative morbidities.

Introduction

When performing liver or biliary tree resections, hepatobiliary surgeons can achieve R0 resection and prevent surgical issues brought on by unexpected bleeding by being aware of the various vascular anatomy of the upper gastrointestinal region [1], [2]. To accurately diagnose liver abnormalities and precisely estimate hepatic vessels, it is crucial to comprehend the anatomy of the liver and its various segments before surgery. Whatever method is used to approach the tributaries, understanding their anatomy and variations is essential to reducing blood loss and operative morbidity. Imaging methods such as multi-detector computed tomography (MDCT), magnetic resonance imaging (MRI), computed tomography angiography (CTA), and magnetic resonance cholangiopancreatography (MRCP) may help in liver resection by evaluating the hepatobiliary anatomy [3].

The hepatic veins, large intraparenchymal veins, drain the liver into the inferior vena cava (IVC). There are typically three hepatic veins: The right hepatic vein (RHV), middle hepatic vein (MHV), and left hepatic vein (LHV). Hepatic veins (IVC) deliver the liver's deoxygenated blood to the IVC. The liver receives about 75% of its blood from the portal vein (PV) and 25% from the hepatic artery. Only the hepatic veins transport blood away from the liver, despite the fact that it receives blood from two different sources [3].

In contrast to the larger RHV, which travels only a short distance of 1 cm extrahepatic, the smaller, middle, and LHV frequently join a common trunk that is 1–2 cm long before entering the IVC. In exceptional circumstances, the LHV and MHV will provide separate drains to the IVC. The umbilical vein typically lies anterior to the umbilical fissure, and empties primarily into the LHV, but it can also connect to the MHV or split into the LHV and MHV to form a trifurcation. Despite the fact that intrahepatic venous branching can vary greatly, common branches are frequently present. The RHV serves as the primary drainage system for the posterior sector, and its branches typically drain into the main trunk from the right. A significant right-sided branch that serves as segment VIII's main drainage is frequently drained by the MHV. The LHV and umbilical

vein branches typically provide the venous drainage for Segment IV. Accessory hepatic veins, which are typically an inferior RHV that drains into the vena cava without passing through the RHV, most frequently affect the right side of the liver [3].

The common bile duct (CBD), PV, and hepatic artery all pass through the porta hepatis, according to conventional anatomy. The bile duct runs anteriorly and to the right of the PV, whereas the hepatic artery travels anteriorly and to the left of it. After branching off the gastroduodenal and right gastric arteries, the hepatic artery, which originates from the celiac trunk, becomes the proper hepatic artery. The left and right hepatic arteries are where they divide next. Segments II/II and IV are reached by extrahepatic lateral and medial branches of the left hepatic artery (LHA), respectively. Anterior and posterior branches usually separate the right hepatic artery (RHA) [4].

Changes in arterial anatomy, such as substituted or accessory right or left hepatic arteries originating from the left superior mesenteric or gastric arteries can be found in 40% of cases. These include a replaced common hepatic artery (CHA), a very short CHA origin from the celiac, a replaced or accessory RHA arising from the superior mesenteric artery (SMA), and a replaced or accessory LHA arising from the left gastric artery (LGA). The substituted branch supplies a complete blood supply to a completely hemi-liver. The PV, also known as the “vena portae,” is a vital blood vessel that carries blood from the digestive tract and spleen to the liver. Around 75% of the liver’s blood comes from the PV, with the remaining 25% coming from the hepatic artery itself [4].

The PV is produced by the union of the splenic and superior mesenteric veins. The splenic and superior mesenteric veins converge behind the pancreatic neck, where they give rise to the PV. It ascends past the hepatic artery and CBD into the liver’s hilus, where it divides into two PVs: a larger right PV and a smaller left PV. The left branch supplies the left liver through the umbilical fissure. The right branch splits into the right anterior and right posterior sector branches after taking a much shorter extrahepatic course [4]. The most frequent anatomical variation is right PV bifurcation, where the anterior and posterior sector branches either lack a main right PV or have separate origins [5], [6].

With this background, the present narrative review of the literature study was undertaken with the main aim of describing and delineating the anatomy and variants of hepatic resectional surgery reiterating the importance of identification of the anomaly.

Materials and Methods

We have retrospectively evaluated the PubMed databases, Embase, and the Cochrane Library by applying various combinations of subject-related terms. The search terms identified with the medical subject heading were “anatomy, hepatectomy, resection, variants.” The databases were used to collect the literature published since 1991. Inclusion criteria were reports that included the following: “anatomy, right hepatectomy, resection, variants.” The exclusion criteria were as follows: Case reports, letters, comments, and abstracts. Duplicate reports and studies that contained non-cancer patients were also excluded from the study. No language restriction was applied in the search strategy. Two independent researchers performed the review. The PRISMA guidelines were followed during all stages of this systematic review. Recommendations were: Pprotocol, research question, search strategy, study eligibility, data extraction, study designs, risk of bias, publication bias, heterogeneity, and statistical analysis.

The systematic literature search found 2500 articles, 330 of which were duplicates and were excluded from analysis. The titles and abstracts from the remaining 2170 articles were assessed. After careful evaluation, 2160 articles were determined to be unrelated to our study and subsequently excluded. The full text of the remaining 10 articles was thoroughly assessed. Case reports, editorials, letters to the editor, and general reviews were then excluded. A total of 7 articles were ultimately included in this review, describing laparoscopic subcutaneous repair of concomitant ventral hernias and rectus diastasis. After excluding repetitive reports, four manuscripts comprised the relevant literature for this review article. The terms “hepatic,” “artery,” “anatomic,” and “variations” were used, as well as combinations of them.

To identify any studies that were overlooked, the references of all relevant articles were checked. The following are the criteria for data inclusion in the study: (1) The research was either an original article or a review, (2) only studies involving adult humans were chosen, (3) populations that overlapped with others were eliminated, and (4) only English-language articles were used. Michels established the classification of the celiac trunk. The year of publication, type of study (case report, case series, and systematic review), and type of patients (living or cadavers) were all investigated for each study considered eligible.

Results

Hepatic veins anatomy and variants

After analyzing 118 scans, Cawich *et al*. found that major hepatic veins could only be seen in 39% of images using traditional anatomy. Among the accessory RHVs discovered in 49.2% of the samples were a well-defined inferior RHV draining segment VI

(45%) and a middle RHV (MRHV) (4%). Eighty-three of the 118 people (or 70.3%) with superior RHVs (SRHV) (Nakamura and Tsuzuki type I) at the hepatocaval junction (HCJ) received no tributaries within 1 cm of the junction. A total of 35 people (29.5%) had a short SRHV with at least one variant tributary. According to Nakamura and Tsuzuki's taxonomy, there were 24 type II variations (20.3%), 6 type III variants (5.1%), and 5 type IV variants (4.2%) [7].

A thorough analysis of the hepatic vein variations in 500 patients was carried out by Sureka *et al*. Their findings showed that 458 individuals (91.6%) had only one RHV, 36 patients (2.6%), and 0.6% had two or more RHVs. 37% had inferior accessory RHV. Out of 185 patients, 1, 2, and 3 accessory inferior RHVs were found in 128, 43, and 14 patients, respectively. Small RHV with well-developed MHV was seen in 1.2% of the patients. While 19% of patients had separate MHV and LHV drainage into the IVC, 81% of patients had a common MHV and LHV trunk. The three veins that segment IV veins most frequently drained into were the LHV, MHV, and IVC. The umbilical vein was observed to drain into the LHV in 16.2% of the patients. While 0.6% of patients had drainage into the MHV, 99.4% of patients had drainage into the left median or segment III veins. The segment VIII vein in the anterior superior segment, where drains into the MHV in 88.6% of patients, and the RHV in 11.4% of patients [3].

Hepatic artery anatomy and variants

The prevalence of overall abnormal hepatic arteries was reported to be 27.41% in the retrospective study by Choi *et al*., which included 5625 patients. The prevalence of abnormal right hepatic arteries (aRHA) was reported to be 15.63%, the prevalence of abnormal left hepatic arteries (aLHA) to be 16.32%, and the prevalence of both aRHA and aLHA to be 4.53%. Patients with aRHA had a higher likelihood of having an aLHA than those without aRHA (29.01% vs. 13.97%; p = 0.001), and patients with aLHA had a higher likelihood of having an aRHA (27.78% vs. 13.26%; p = 0.001). All RHAs coming from the proximal to middle CHA had retroportal courses, so they were all regarded as aberrant hepatic arteries. The authors defined RHAs come from the gastroduodenal artery, SMA, celiac trunk, aorta, and LGA, and LHAs come from the LGA, celiac trunk, aorta, and SMA. The distal CHA was used to derive RHA and LHA, which were considered minor variations. This is due to the fact that their choledochus and PV still follow a traditional anatomical course. ARHAs derived from the splenic artery (n = 2) or LGA (n = 1), and aLHAs derived from the aorta (n = 1) or SMA (n = 1), were among the extremely rare variations seen in this study. The patient who had an aRHA and an aLHA from the SMA also had an aRHA and an aLHA from the LGA. The SMA-derived aRHA displayed a retroportal course [8].

Noussios *et al*. performed a thorough search of the scientific literature for the years 2000–2015 on 19,013 patients using the PubMed and Scopus databases. Their findings showed that the anatomy was normal in 81% of the cases. In 3.7% of cases, a replacement RHA comes from the SMA, and in 3% of cases, a replacement LHA comes from the LGA. A replacement RHA and a left one were both found in 0.8% of cases, whereas an accessory LHA and an accessory RHA were found in 3.2% and 1.6% of cases, respectively. A CHA coming from the SMA was observed in 1.2% of cases. Not to mention, 784 cases (4.1%) discovered in the investigation were uncommon unreported anomalies [9].

Coco *et al*. in their retrospective review study, delineated that, the RHA branch of the SMA (type III, n = 27, 5.63%), the LHA branch of the LGA (type II, n = 13, 2.71%), and the RHA arising from the SMA associated with the LHA arising from the LGA (type IV, n = 4, 0.83%) were the most frequent. According to Hiatt's categorization, the right hepatic accessory artery or replacement of the SMA (type III, n = 28, 6.05%) was the most common modification, followed by the left liver ancillary artery or replacement of the LGA (type II, n = 16, 3.34). The highest frequency of hepatomesenteric trunk anomalies was seen in 5 donors (01.04%), and it was present in 14 donors (2.92%) [10].

PV anatomy and variants

The anatomy of a typical PV is explained as follows. The left PV branch and the right PV branch are formed when the portal trunk splits in the liver hilum. Right anterior PV feeding segments V and VIII and right posterior vein feeding segments VI and VII are the two branches that arise from the right PV branch (type 1). Anatomical variants are any deviations from this anatomy. In investigations using multidetector computed tomography (CT) with reconstruction of the portal anatomy, 65%–80% of patients had normal anatomy [11], [12]. The most common variation (type 2) is the so-called "PV trifurcation," in which the main PV divides into the left PV, the right anterior PV, and the right posterior PV. The second most common form (type 3) is a right posterior PV that originates from the PV's first branch. These two variations account for the majority of the main PV variance. The most effective technique seems to be 3D reconstruction using thin axial CT images, with reported occurrences of 27% and 35% [11], [12], [13]. Type 3 was twice as common as type 22 in the study by Atasoy and Ozyürek, (23.5 and 9.5%, respectively) [11]. The incidence of type 2 and type 3 was reported to be 9% and 13%, respectively, in Covey *et al*., investigation [13]. Furthermore, trifurcation of the right posterior branch of the PV was slightly more frequent than early origin (11.1% and 9.7%, respectively) in another study with 1384 patients [12].

A retrospective analysis of 1000 patients using triphasic MDCT abdomen scans was carried

out by Sureka *et al*. Their results delineated that the anatomy was regarded as normal (type I) in 773 cases (79.94%). Trifurcation (type II) variation was seen in 6.0% of the cases. The right posterior vein served as the MPV (type III) variant's initial branch in 5.0% of cases. Type IV variation and type V variation (Type IV: separate origin of the Segment VII branch from the RPV; Type V: separate origin of the Segment VI branch from the RPV) were observed in 2.69 and 1.34% of cases, respectively [3].

Bile duct normal anatomy and variants

In 1957, Couinaud and Nogueira first introduced the concept of modal and aberrant anatomy by focusing on the liver [14]. Anatomical differences in up to 47% of extrahepatic biliary tracts (EHBT) have been reported. The accessory cysticohepatic ducts, accessory hepatic ducts, ducts of Luschka, low cystic duct (CD) insertion, CD insertion into the right or left hepatic duct (RHD or LHD), CD insertion into the left side of the common hepatic duct (CHD), left CD insertion, short CD, long CD, and double CD are some of these variations [15], [16], [17], [18].

The first variation has a prevalence in the general population that ranges from 0.6% to 2.3% and involves the right hepatic duct and CD joining [19]. In the second variant, the CD was joined to the left hepatic duct. This anatomical variation is extremely rare [20], [21], [22]. The CHD may develop at the hepatic hilum with a variant known as the triple confluence. A moderately common variant, CHD affects 11% of the general population and is formed when the right anterior and posterior bile ducts join the left bile duct [23], [24], [25].

According to Kitami *et al*., the right posterior sectoral duct joins the left hepatic duct with a supraportal course, the right posterior sectoral duct joins the right anterior sectoral duct with an infraportal course, trifurcation variation of the biliary tree, retroportal course, and left lateral segmental ducts caudal to the umbilical portion of the PV are examples of variant biliary anatomy encountered in PV variations [26].

CBD duplication

A very uncommon congenital biliary system defect is the duplication of CBD (DCBD). The most recent taxonomy divides DCBD into five different categories. The types of DCBD are explained as follows using Choi *et al*. classification: Type I, where the CBD is divided by a septum; Type II, when the CBD divides at the distal end and drains into each opening separately; Type III includes duplicated biliary drainage with intrahepatic communicating channels (Type IIIa) or without them (Type IIIb); Type IV includes duplicated biliary drainage with one or more communicating channels; and Type V includes duplicated extrahepatic bile ducts rejoined as single drainage with communicating channels (Type Va) or without them (Type Vb) [8].

Discussion

The liver anatomy appears to be very complex due to the enormous number of vascular and biliary branches as well as the fact that the underlying pathology frequently distorts the anatomy [27]. According to the terminology known as Brisbane 2000 Terminology of Liver Anatomy and Resections, which is the most popular segmentation system. The liver is segmented into two parts: The left liver, also known as the left hemi-liver, and the right liver, also known as the right hemi-liver. The left liver (segments 2 through 4) and the right liver (segments 5 through 8) are separated by what is known as the first-order division, and resection of either is referred to as a left hepatectomy or left hemi-hepatectomy. The second-order division further divides the right and left livers into four sections: The right anterior section (comprising segments 5 and 8), the right posterior section (comprising segments 6 and 7), the left medial section (comprising segment 4), and the left lateral section (comprising segments 2 and 3). A corresponding sectionectomy is the term used to describe the removal of these sections. These sections are divided into segments in the third division, and the removal of these segments is known as a segmentectomy [28].

To prevent harm to the celiac trunk, CHA, and hepatic arteries during surgical or invasive procedures, it is advised to be aware of the normal structure and variations of the arteries. The human liver has very different venous drainage. Hepatic surgeons, general surgeons, transplant surgeons, interventional radiologists, and other medical specialists who treat liver problems must have a thorough understanding of this information [7]. The RHV anatomic pattern has a wide range of proposed descriptions and classifications, making it complex. According to most reports, a major trunk arises at the junction of two tributaries in the plane between the right anterior and posterior liver regions. Segments V and VIII of the liver are drained by the anteromedial tributary (AMT), while segment VI is drained by the posteroinferior tributary (PIT). These branches come together to form the SRHV, the main RHV stem that ascends to the IVC. The right superficial vein, a persistent tributary draining section VII, intersects the SRHV on its posterolateral side. There have been conflicting reports of a tributary draining the posterior half of segment VIII and entering the medial portion of the SRHV, which is frequently referred to as the dorsal vein for segment VIII [29], [30], [31], [32], [33], [34], [35].

Any additional vessels from the right liver draining into the IVC are referred to as accessory

RHVs in traditional anatomical descriptions, which only include one SRHV draining into the IVC. There are three distinct variations. More than 2 cm from the HCJ, an inferior RHV drains segment VI and connects to the IVC just above the inferior border of the liver. Within 1–2 cm of the HCJ, the MRHV drains segment VII and empties directly into the IVC. The LHV normally runs between segments II and III in a plane of the section before emptying into the IVC. The intersection of the left inferior median vein (LIM) and the right inferior median vein (RIM) is where the MHV emerges. It receives tributaries from both hemispheres of the liver known as the left and right superior middle vein branches as it moves cranially in the midplane of the liver to enter the IVC. The AMT, which drains segment V, and the PIT, which drains segment VI, meet at the point where the hepatic vein confluences to form the RHV. The SRHV, which rises to the IVC, is formed when the two tributaries combine. The SRHV frequently connects to a tributary draining segment VII from its posterolateral side [29], [30], [31], [32], [33], [34], [35].

About 20% of cases of the hepatic artery have anatomical variations. Many authors have proposed various international classifications, including Adachi in 1928, Michels in 1966, Hiatt in 1994, and Abdullah in 2006 [36]. Despite these investigations, there are still a few peculiar liver abnormalities that are not covered by these categories. Michels identified 10 different types of hepatic artery variations using the findings of 200 cadaver dissections. All upcoming research on variation will be guided by the Michels classification [9], [37], [38], [39]. The Michels classification is explained as follows; (I). Normal anatomy, (II). Replaced LHA from LGA, (III). Replaced RHA from SMA, (IV). Replaced LHA from LGA and Replaced RHA from SMA, (V). Accessory LHA from LGA, (VI). Accessory RHA from SMA. (VII). Accessory LHA from LGA and accessory RHA from SMA, (VIII). Replaced LHA and Accessory RHA or Replaced RHA and Accessory LHA, (IX) CHA from SMA, and (X). CHA from LGA. Abnormal-course hepatic arteries may be more susceptible to ischemic damage caused by excessive dissection during surgery. In the context of pancreaticoduodenectomy, iatrogenic injury to aRHAs can result in biliary enteric anastomotic ischemia [40], [41].

Our study yielded type 1 findings (normal) in 72.59% of patients, type 2 findings (aLHA of LGA) in 11.70%, type 3 findings (aRHA from SMA) in 6.95%, and type 4 findings (aLHA from LGA and aRHA from SMA) in 3.15%, all according to the Hiatt classification system [42]. Hiatt types 1–4 were not used to categorize anatomical variations, so they were categorized as others. Many rare anatomical variations not categorized by the Michels and Hiatt classification systems: aRHAs and aLHAs reported in the literature as 0.33–3.33% and 0.21–2.00%; aRHAs and aLHAs derived directly from the aorta are reported as 0.08–1.43% and 1.43–1.67%, respectively; aRHAs arising from the splenic artery; aLHA arising from the SMA; aRHAs originating from the LGA.

A more recent review of the literature study carried out by Yi *et al*. revealed that the trifurcation occurs in 87.6% of cases, which is higher than the literature's reported range of 60.0%–94.2% for the trifurcation of tripus Halleri [43]. The literature contains a large number of studies on the variations in the hepatic arteries. A recent study found that while accessory RHA and LHA occur in 0.8–8% of cases, replacement RHA and LHA occur in 11–21% and 3.8–10% of cases, respectively, of hepatic arterial tree abnormalities [44]. Whatever method is used to approach the tributaries, understanding their anatomy and variety is essential. Following inflow, the RHV is split, most frequently extrahepatically. The MHV is where the incision is made. The primary venous drain from segment VI may be a large inferior RHV. When the vena cava mobilizes the liver, this must be shared. A branching pattern of standard anatomy is present in only 65% of cases. Trifurcation variation, the most frequent anatomical variant of MPV, is followed by RPPV as the initial branch of MPV. The separate origin of the Segment VI PV branch from the RPV, separate origin of the Segment VII PV branch from the right PV, and separate origin of the Segment VI and VII PV branches from the right PV are examples of RPV variants that have been described in the literature. Segment VIII provided by the right and left PV branches, Segment VIII supplied by the left PV branches, and Segment IV supplied by the right and left PV branches are the segmental PV variations that are detailed [4].

The right PV has a wide range of anatomical appearances, from a long segment to the sectoral/segmental junction to its complete absence with immediate branching into segmental/sectoral branches. In addition, the main PV may divide into the right anterior and posterior sectors, leaving no right PV at all. Finally, the left tributary may give rise to the right anterior PV and pedicle, which calls for intrahepatic control. A small posterior branch to the caudate process is almost always produced by the right PV. During extrahepatic dissection, bleeding from it occurs frequently. The RHA typically runs posterior to the CHD, but in 10–20% of cases, it runs anterior to the duct. In the porta hepatis, between the PV and CBD, the RHA runs posteriorly and is frequently replaced [5].

There have been reports of less common PV variations, but it has not been determined that they happen more often than 2% of the time. In quadrification, the PV divides into a left portal branch and three distinct right portal branches, the so-called "lack of PV bifurcation" is a more complicated variant. In the latter case, there is no origin of the left portal branch, and the liver hilum receives only one right portal branch from the PV [11], [34]. Segment VIII generates a major portal branch that crosses segments VIII and VI, terminates in the umbilical portion of the PV, and then generates a minor portal branch from the left that

gives rise to Segments II, III, and IV branches. The final rare PV mutation is referred to as "fusion of the central plane of the liver." There are two main hepatic veins in addition to a hypotrophied medial hepatic vein, and the ligamentum teres is situated next to the gallbladder. The PV typically divides into a right posterior branch, a left posterior branch, and a main medial branch that ends in the ligamentum teres. All of these abnormalities are connected to this variant. This variation occurs in <0.5% of patients, and it is highly rare [45].

The division of right portal branches has been assessed in Japanese literature using the Takayasu classification [46]. Wu *et al*. reported that 70% of cases involve the right portal branch's normal division (i.e., two main branches). Segments V and VIII of the right liver's anterior portion have two branches, whereas segments VI and VII of the posterior portion have two separate branches. The absence of distinct right posterior branches but abrupt bifurcation into segments VI and VII's two branches is the most frequent variation (20% of cases). Another distinction is whether the segment V branch arises from the right posterior PV or the right PV itself [47].

Another notable anatomical variation is segmental portal branches, which theoretically separate the left and right livers. They pass through the liver's center. Only segments IV and VIII that are fed by branches that come from the opposite side are affected by this, which was only discovered in 4% of cases [34]. A survey study by Dundaraddy and Mahesh revealed that because the EHBT is one of the frequently encountered anatomical variant locations, surgeons place a high priority on its anatomy. Moreover, it is one of the most well-liked places for medical procedures. In EHBT, aberrant anatomy can occur up to 47% of the time [48]. Furthermore, Kullman *et al*., reported that 19% of EHBTs had anatomical alterations [49]. Moreover, Hasan *et al*., latest's research reported a 15.2% incidence [50]. However, it was found to be 8.8% as determined by De Filippo *et al*., [51] and 7.3% was reported by Cachoeira *et al*. [52].

According to Khayat *et al*., 30% of patients had unusual anatomy [53], which is higher than the percentages found in Lamah and Dickson [15], and Talpur *et al*., [16] research studies. An abnormal anatomy was found in 30% of the EHBT. The most frequent defect was left CD insertion, followed by short CD. Surgeons are able to perform surgery without endangering the biliary tract by being aware of these common irregularities in this region. The aberrant anatomy was connected to the increased risk of biliary tract damage, but there was no link to the formation of biliary stones [53].

Understanding the anatomical variations in hepatic vascular architecture is essential in general surgery, especially in hepatobiliary and pancreatic surgery. This information is crucial for laparoscopic surgery, radiographic treatments, and the management of penetrating injuries to the peri-hepatic region. The surgeon can more easily foresee a vascular aberration thanks to the preoperative delineation of the vascular anatomy provided by CTA. Unless the need to divide or remove abnormal vessels is necessary to obtain oncological clearance, abnormal vessels should be carefully dissected and preserved, if at all possible [54].

DCBD is a very uncommon congenital biliary anomaly. Since Vesarius first described it in 1543 cases, there have only been 24 cases reported in the Western literature [55]. However, cases of DCBD are frequently reported in eastern literature. Yamashita *et al*. looked into a total of 47 patients who had been written about in Japanese literature [56]. Chen *et al*. reported 24 Chinese instances in 2014 [57]. It is believed that an anomaly during embryogenesis is what causes this biliary system anomaly. Anatomically, the early stages of human development are characterized by the presence of two bile ducts. However, because the second bile duct cannot retract, a persistent auxiliary extrahepatic bile duct forms [8], [58]. Goor and Ebert proposed the initial classification of DCBD based on anatomical appearance [59]. The categorization that was then most frequently used was updated by Choi *et al*. in 2007. DCBD is divided into five categories based on the Choi classification. In contrast to the Western and Japanese populations, where it is lower (3.6%, 8.5%, and 58.3%, respectively), the proportion of type I DCBD in the Chinese population is higher than that of any other type [8]. The review study reported by Yamashita *et al*. revealed that 12 out of 47 recruited patients received cancer diagnoses, including pancreatic, stomach, gallbladder, and ampullary cancer. These phenomena might be partially brought on by persistent stomach or pancreatic juice reflux into the extrahepatic bile duct [56].

Conclusion

To accurately diagnose liver abnormalities and precisely estimate hepatic vessels, it is crucial to comprehend the anatomy of the liver and its various segments before surgery. Whatever method is used to approach the tributaries, understanding their anatomy and variations is essential to reduce blood loss and operative morbidity. Imaging methods such as MDCT, MRI, CTA, and MRCP may help in liver resection by evaluating the hepatobiliary anatomy.

Author's Contributions

Danilo Coco and Silvana Leanza contributed to this paper; Danilo Coco designed the overall concept and

outline of the manuscript; Silvana Leanza contributed to the discussion and design of the manuscript; Danilo Coco and Silvana Leanza contributed to the writing, and editing the manuscript, illustrations, and review of the literature.

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