1 Surgical Anatomy of the Liver

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- *The morphologic anatomy of the liver, based on superficial landmarks, has been replaced by functional anatomy, which is more appropriate for liver surgery.*
- *The liver is divided according to portal pedicles and hepatic veins. Cantlie's line (where the middle hepatic vein is located) divides the liver in right and left hemilivers.*
- *The right hemiliver is divided in anterior (segments 5 and 8) and posterior (segments 6 and 7) sectors by a plan where the right hepatic vein is located.*
- *The left hemiliver is divided in medial (segment 4) and lateral (segments 2 and 3) sectors.*
- *Segment 1 corresponds to the caudate lobe, located around the vena cava.*
- *Vascular and biliary variations are very frequent and they have significant implications on liver resections and/or transplantation.*

INTRODUCTION

Knowledge of hepatic anatomy has evolved since the first anatomic liver resection by Lortat-Jacob in 1952. The anatomy currently used is based on descriptions made by Hjörstsjö and by Couinaud. These comprehensive papers divided the liver in segments or sectors according to its vascularization and biliary drainage. Modern hepatic surgery is based on the concept that the future remnant liver must have enough hepatic parenchyma but also adequate blood inflow (arterial and venous), blood outflow, and biliary drainage. The comprehension of the complex anatomy of the liver allowed the development of highly structured hepatic procedures such as staged resections and living liver donor transplantation.

Liver anatomy can be described using mainly two different aspects: morphological anatomy and functional anatomy. Traditional morphological anatomy (**Figure 1**) is based on the external appearance of the liver and does not take into account internal features such as vessels and biliary duct branching, which are of obvious importance in hepatic surgery. Functional anatomy (**Figure 2**) is based on the internal architecture of the liver and constitutes the basis for modern surgery of the liver.

Total liver volume has a relatively constant relationship to body weight, although liver/body weight ratios are greater in growing individuals than in adults. Various formulas can be used to estimate total liver volume in adults. One that is frequently used in Western subjects is based on the linear correlation between TLV and body surface area (BSA): Total Liver Volume (in cm^3) = -794.41 + 1,267.28 × BSA (in m^2) (see **Chapter 4** – Underlying Liver Disorders in Hepatic Surgery). In general, the left hemiliver comprises about one-third of the total weight of the liver in humans. However, the ratios of the left and right hemiliver volumes to total liver volume vary considerably among individuals. Therefore, the remnant liver volume after a hepatectomy or the volume of the graft in a case of living donor liver transplantation cannot be accurately predicted preoperatively on the basis of the donor body weight alone.

Silvio Marcio Pegoraro Balzan and Vinicius Grando Gava (Eds.)

The liver receives a dual blood supply from the hepatic portal vein and hepatic arteries. Approximately 75% of the liver's blood supply is through the hepatic portal vein, which carries venous blood drained from the spleen, gastrointestinal tract, and its associated organs. The hepatic arteries supply arterial blood to the liver, accounting for the remainder 25% of its blood flow. Oxygen is provided from both sources; approximately half of the liver's oxygen demand is met by the hepatic portal vein, and the hepatic arteries meet the other half. Blood flows through the sinusoids and empties into the central vein of each lobule. The central veins coalesce into hepatic veins, which leave the liver and empty into the inferior vena cava.

The term "biliary tree" derives from the arboreal branches aspect of the bile ducts. The bile produced in the liver is collected in bile canaliculi, which merge to form bile ducts. Within the liver, these ducts are called intrahepatic bile ducts, and once they exit the liver parenchyma they are considered extrahepatic. The intrahepatic ducts eventually drain into the right and left hepatic ducts, which merge to form the common hepatic duct. The cystic duct from the gallbladder joins with the common hepatic duct to form the common bile duct.

MORPHOLOGIC ANATOMY

The liver is located in the right upper quadrant of the abdominal cavity, resting just below the diaphragm and under cover of the lower ribs. Most of the liver lies to the right of the midline, where the lower border coincides with the right costal margins, and a small portion lies immediately behind the anterior abdominal wall in the epigastrium, between the anterior surface of the stomach and the left dome of the diaphragm. The upper surface is boldly convex, molded to the diaphragm, and the surface projection on the anterior body wall extends up to the fourth intercostal space on the right and the fifth intercostal space on the left. The convexity of the upper surface slopes down to a posterior surface, which is triangular in shape. The posterior surface is enclosed by the leaves of the coronary and the triangular ligaments, and lies in contact with the inferior vena cava. It is a relatively soft organ, mostly covered by a thin fibrous capsule – Glisson's capsule (an extension of the peritoneum) – except on the posterior surface, where the peritoneum reflects onto the diaphragm, forming the right and left triangular ligaments (**Figure 1**). The undersurface of the liver is concave and extends down to a sharp anterior border. It contains a fissure (the hilum or *porta hepatis*), by which the major vessels and bile ducts enter and leave the liver. The liver is suspended from the anterior abdominal wall and the diaphragm by the falciform ligament and three other peritoneal folds. The round ligament (*ligamentum teres*), formed by the obliteration of the umbilical vein, arises from the end of the left portal branch and forms the lower, visceral border of the falciform ligament. It is connected to the diaphragm and abdominal walls by five ligaments: the membranous falciform (which also separates the right and left lobes), coronary, right and left triangular ligaments, and the fibrous round ligament. They have no functional importance, but they are easily recognizable surface landmarks.

Traditional gross anatomy divided the liver into four lobes based on surface features. The falciform ligament divides the liver into a left anatomical lobe, and a right anatomical lobe, the right lobe is considerably larger than the left. If the liver is flipped over (**Figure 1C**), or visualized from behind (**Figure 1B**), two morphological additional lobes can be individualized. They are the caudate lobe and quadrate lobe.

From behind, the lobes are divided up by the *ligamentum venosum* and *ligamentum teres* (the parenchyma and other

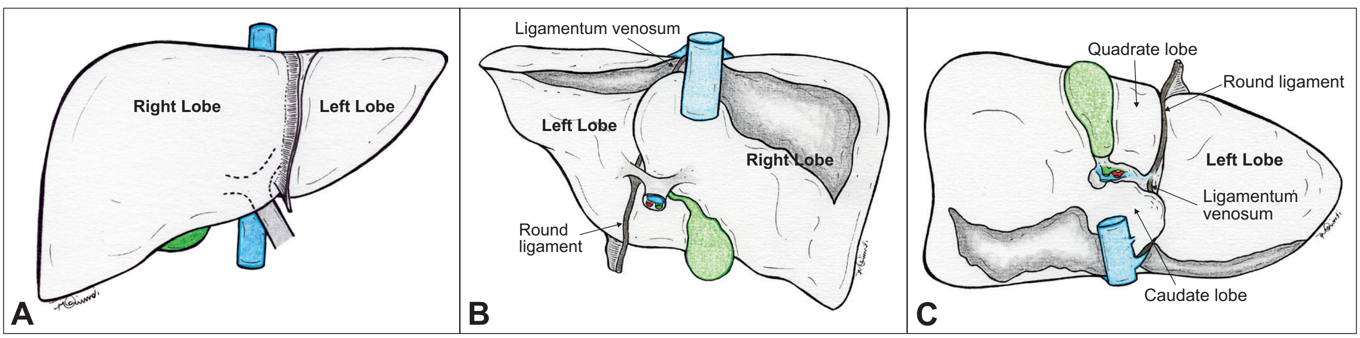

Figure 1. A) Anterior view. The liver is divided in two main lobes by the falciform ligament. The right one is larger than the left one. **B**) Dorsal view. The IVC lies snugly in a deep groove within the bare area; the hepatic veins open directly into it. Occasionally, the liver tissue embraces the vena cava completely so that it runs within a tunnel of parenchyma. **C**) Inferior view. The portion of the right lobe located anterior to the hilar fissure is called the quadrate lobe, limited on the left by the umbilical fissure and on the right by the gallbladder fossa. The caudate lobe is seen posteriorly to the transverse hilar fissure. The gastrohepatic omentum is attached to the ligamentum venosum (or Arantius ligamentum), lying between the caudate lobe (that is placed within the lesser omental sac) and the left hepatic lobe.

hepatic structures on the left of these ligaments pertain to the morphological left lobe). The transverse fissure (or *porta hepatis*) divides the caudate from the quadrate lobe, and the right sagittal fossa, which the inferior vena cava runs over, separates these two lobes from the right lobe.

Occasionally, anatomical variants of a hepatic lobe, such as the Riedel lobe, may be present and confused for a mass (**Figure 3**).

BASIC ANATOMY OF THE HEPATIC HILUM

The hepatic hilum (and the hepatoduodenal ligament) is, for the most part, composed of three layers: the portal vein in its most dorsal aspect, the hepatic artery in the middle, and the bile duct in its most ventral aspect (**Figure 4**). The anatomy of the **portal vein** is generally very regular. Its bifurcation is located on right portion of the hepatic hilum. Its left branch consists of a transverse portion that runs from the bifurcation of the main portal vein to the *ligamentum venosum*, and an umbilical portion that runs upward in the umbilical fissure. The **bile duct** normally follows an extrahepatic course very similar to that of the portal vein. The confluence of right and left hepatic ducts is located more cranially than the main portal vein and proper hepatic artery bifurcation. The intrahepatic right and left biliary ducts are situated on the dorsal aspect of right and left portal branches, but immediately before their confluence in the hilar plate they pass anteriorly and the common bile duct and main bile duct assume an anterior situation in the hepatoduodenal ligament. Anomalies of the bile duct are much more common than those of the portal vein. The **hepatic artery** normally divides into a large right branch and a thinner left (and middle) branch more inferiorly in the hepatoduodenal ligament than the division of the portal vein and confluence of right and left hepatic biliary ducts. As a result, both right and left arterial branches have a relatively long extrahepatic course that differs from those of the portal vein and bile duct, especially in regard to the left and middle branch. The right hepatic artery is usually larger and passes behind the bile duct immediately after branding off the proper hepatic artery. The left and middle hepatic arteries travel along the left side of the hepatoduodenal ligament, with no close relationship to the bile duct until the end of the transverse portion of the hilar plate. The hepatic arteries, like the bile duct, are subject to many anomalies, as described below in this chapter, which can necessitate a variety of surgical modifications, especially during liver transplantation and resections.

FUNCTIONAL ANATOMY

The term functional anatomy refers to the description of hepatic segmentation based on the internal architecture of the liver (**Figure 2**) and constitutes the real anatomic basis for modern hepatic surgery. This approach was first made by Cantlie in 1898 and further clarified by the publications of McIndoe and Counseller[1] (1927), Ton That Tung[2] (1939), Hjörstsjö[3] (1951), Healey and Schroy[4] (1953), Goldsmith and Woodburne[5] (1957), Couinaud[6] (1957), Bismuth et al.[7] (1982), and more recently by Takasaki[8] (1998). The description by Couinaud is the most used, and although an increasing number of surgical and radiological observations call Couinaud's concept of eight liver segments into question[9–12], it is still very useful for surgeons. In this functional anatomy, eight segments are numbered in a clockwise direction from an anterior viewpoint, starting with the caudate lobe as segment 1.

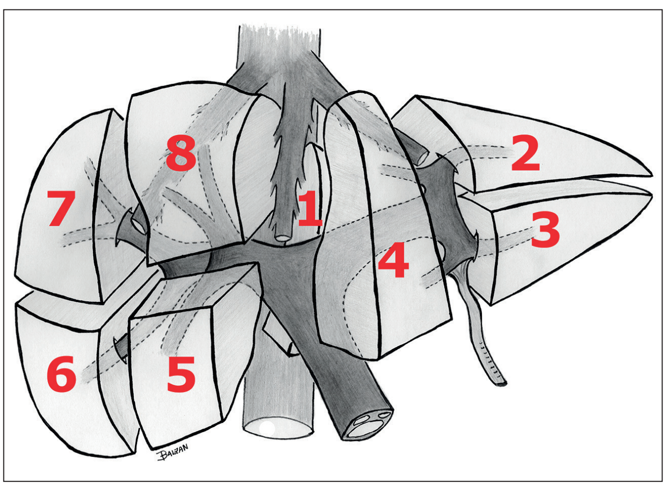

Figure 2. Segmental anatomy of the liver proposed by Couinaud. The middle hepatic vein divides the right hemiliver (segments 5,6,7 and 8) from the left hemiliver (segments 2,3 and 4).

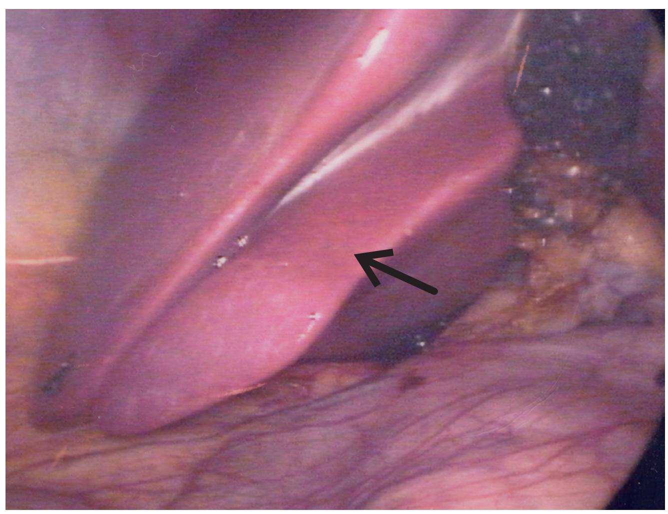

Figure 3. Surgical aspect of a Riedel lobe (arrow), inferior projection of the right lobe, during a laparoscopic cholecystectomy.

The central area where the Glissonean pedicles (also called portal pedicles or portal canals) enter the liver is the hilum or *porta hepatis* (**Figure 4**). The Glissonean pedicles consist of the triad of portal vein, hepatic artery, and bile ducts inside a sheath formed by an extension of Glisson's capsule. At the right of the hilum, the Glissonean pedicle with the biliary duct, portal vein, and artery divide into left and right branches, and the portions of the liver supplied by these branches constitute the functional left and right hemilivers.

An imaginary plane joining the gallbladder fossa to the inferior vena cava, called Cantlie's line, separates the functional lobes. This plane separates the liver into true right and left hemilivers. The middle hepatic vein runs in this plane. The right lobe is further divided into an anterior and posterior segment by the right hepatic vein. The left lobe is divided into the medial and lateral segments by the left hepatic vein. The fissure for the *ligamentum teres* also separates the medial and lateral segments. The medial segment is also called the quadrate lobe. In this widely used Couinaud (or "French") system, the functional lobes are further divided into a total of eight subsegments based on a transverse plane through the bifurcation of the main portal vein. The caudate lobe is a separate structure, which receives blood flow from both the right- and left-sided vascular branches.

A schematic representation of the liver segments through different transverse levels can be seen in **Figure 5**. The middle hepatic vein divides the liver in right and left hemilivers. The right hepatic vein divides the right hemiliver in two sectors: anterior (segments 5 and 8) and posterior (segments 6 and 7). A transverse plane at the level of the right portal vein divides the superior from the inferior segments (segment 7 from 6 and segment 8 from 5). At the level of the left portal vein the left hemiliver is divided in superior (segments 2 and 4a) and inferior (segments 3 and 4b) segments. The left portal vein is at a higher level than the right portal vein. At the level of the splenic vein, which is below the level of the right portal vein, only the inferior segments are seen.

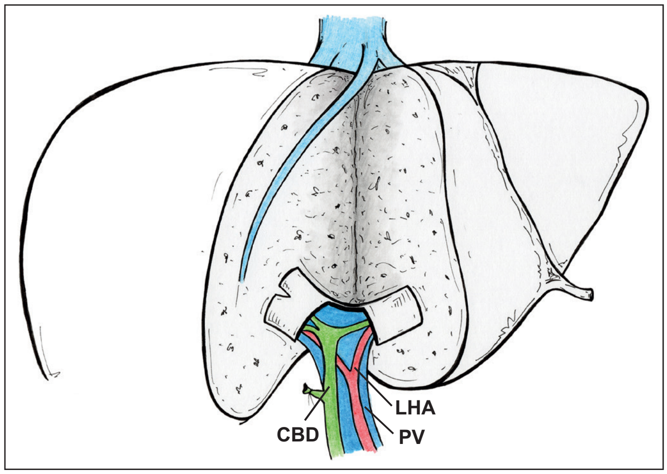

Figure 4. Schematic representation of usual anatomy of the hilar structures. The bile duct (green) is located anteriorly and the portal vein (blue) posteriorly. The right hepatic artery usually runs between the common bile duct and the portal vein. The gallbladder was removed and the cystic duct ligated. CBD: common bile duct; LHA: left hepatic artery; PV: portal vein

The classification of Bismuth et al.[7] is very similar to the Couinaud classification, although there are small differences. According to Bismuth three hepatic veins divide the liver into four sectors, further divided into segments (**Figure 6**). These sectors are termed portal sectors as each is supplied by a portal pedicle in the centre. The separation line between sectors contains a hepatic vein. The hepatic veins and portal pedicles are intertwined, as are the fingers of two hands.

The left portal scissura divides the left liver into two sectors: anteromedial and posterolateral. Left anterior (anteromedial) sector consists of two segments: segment 4, which correspond to the quadrate lobe, and segment 3, which is anterior part of anatomical left lobe. These two segments are separated by the left hepatic fissure or umbilical fissure. Left posterior (posterolateral) sector consists of only one segment (segment 2). It is the posterior and superior part of the left lobe.

The right liver is divided into two portions by the right

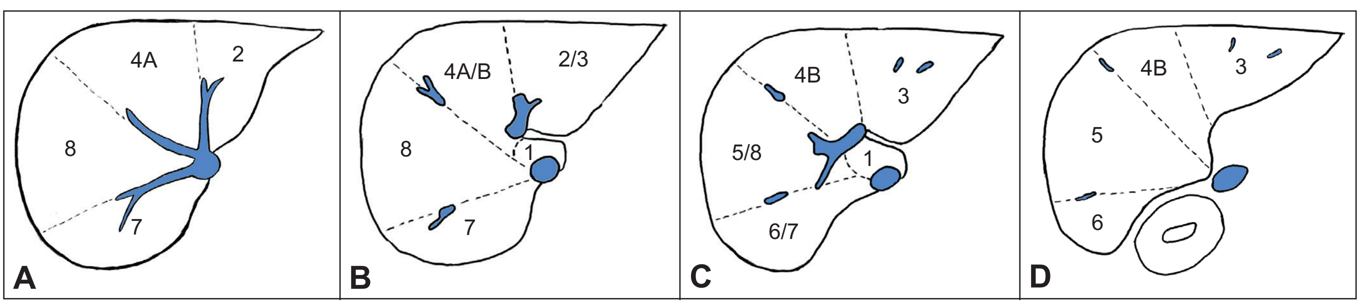

Figure 5. Transverse images through different levels of the liver. **A**) Transverse section of superior segments of the liver divided by the hepatic veins. **B**) Tansverse section at the level of the left portal vein. **C**) Transverse section at the level of the right portal vein. **D**) Transverse section at the level of the splenic vein. Only the inferior segments of the liver are seen. Numbers indicate the Couinaud segments.

portal scissura, which contain the right hepatic vein. The right portal scissura divides the right liver into anteromedial and posterolateral sectors, clearly seen when the liver is placed on a flat table. In situ, however, the liver is molded around the spine, and these two sectors are better described as anterior and posterior sectors. The right portal scissura is inclined approximately 40 degrees to the right. According to Couinaud, it extends from the anterior surface of the liver at the anterior border, midway between the right angle of the liver and the right side of the gallbladder bed, to the confluence of the inferior vena cava and the right hepatic vein posteriorly.

A new concept of liver segmentation on the basis of the Glissonean pedicle proposed by Takasaki [8] describes the blood supply of the liver as derived from three secondary branches of the Glissonean pedicle, and each secondary branch feeds one segment. Consequently, the liver can be separated into three segments: right, middle, and left. There is one additional area, called the caudate area, which is nourished directly from the primary branch. The three segments are almost the same size, each accounting for about 30% of the total liver volume, with the remaining 10% occupied by the caudate area (**Figure 7**).

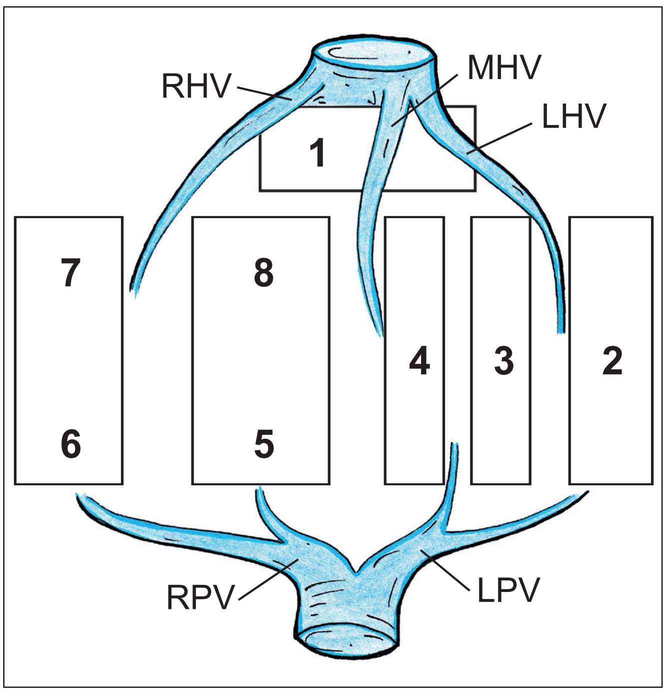

Figure 6. Schematic representation of the liver functional anatomy based on the division by the hepatic veins. Hepatic sectors are delimited by the three main hepatic veins. Note that the caudate (Spiegel) lobe constitutes an independent sector (dorsal) which is not delimited by the hepatic veins (Numbers indicate the Couinaud segments). RHV: Right hepatic vein; MHV: Middle hepatic vein; LHV: Left hepatic vein; RPV: Right portal vein; LPV: Left portal vein. (Modified from Bismuth et al.[7])

HEPATIC VEINS AND INFERIOR VENA CAVA

The venous drainage of the liver comprises three main hepatic veins that drain into the suprahepatic part of the inferior vena cava, and a variable number of accessory hepatic veins that drain into the retrohepatic vena cava. The right hepatic vein, the longest vein in the liver, is single in about 94 percent of cases.[13] The main trunk is formed by the convergence of an anterior trunk situated in the right portal fissure, which drains mainly segments 5 and 6, and a posterior trunk that chiefly drains segment 7.[14] The middle hepatic vein courses along Cantlie's line in the principal portal fissure and forms a common trunk with the left hepatic vein in about 85% of cases.[13,14] It drains the central sector of the liver, receiving constant tributaries from segment 4

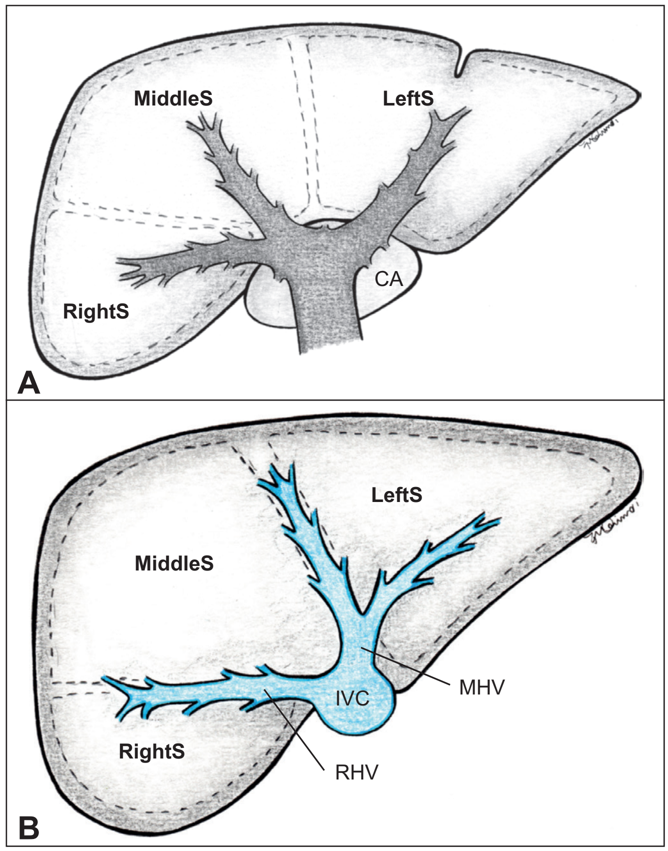

Figure 7. Takasaki's liver segmentation. Differently than other classifications, this segmentation is based on the two major venous trunks (right hepatic vein and middle/left hepatic vein trunk). **A**) Three segments and a caudate area. The left hemiliver of Couinaud's classification corresponds to the left segment. The right anterior sector and right posterior sector of Couinaud correspond to the medial and right segments, respectively. **B**) Relationship between the hepatic veins and the three segments according to Takasaki. RightS: Right segment; MiddleS: Middle segment; LeftS: Left segment; CA: Caudate area; IVC: inferior vena cava; RHV: right hepatic vein; MHV: middle hepatic vein.

on the left, and from segments 5 and 8 on the right.[15] It is often the main vein draining the anterior segment of the right lobe. The left hepatic vein arises from the confluence of a transverse vein, draining segment 2, and a sagittal vein, draining segment 3.[14] It occasionally receives a contribution from segment 4.

Short accessory (dorsal) right hepatic veins, not to be mistaken with the caudate lobe veins, drain the dorsal sector of the liver (mainly segments 6 and 7) and empty directly into the retrohepatic inferior vena cava on its right.

In 1981, Nakamura and Tsuzuki [13] made an extensive study of the patterns of the ramifications of the hepatic veins, and observed that the size of the main right hepatic vein seemed to determine the number of accessory hepatic veins and their diameters. In the presence of a large hepatic vein draining a wide area of the right lobe, only a small posterior vein drains a small area of the posterior sector of the right lobe, with occasional absence. If the main right hepatic vein is medium sized, a posterior or posteroinferior vein, 0.5 to 1 cm in diameter, drains the posteroinferior segment (segment 6) of the right lobe separately into the vena cava. In just under a quarter of livers, however, the right hepatic vein is small and short, and drains only segment 7, while a large posterior or posteroinferior vein, up to 1.8 cm in diameter, drains the bulk of the posteroinferior area of the right lobe. In such circumstances the anterior segments can drain solely into the middle hepatic vein. The peripheral course of the hepatic veins appears to be the most important cue for the identification of the portal segments, because these veins are thought to run along the sectorial and/or segmental borders. The right hepatic vein runs between the anterior and posterior sectors, i.e., between segments 5 and 6 and between segments 7 and 8. However, some researchers have reported that when the right hepatic vein is poorly developed it does not reach the border of segments 5 and 6.[13,16] In addition, Masselot and Laborgne [16] found a well-developed middle hepatic vein draining segment 6 in 23% of the cases they examined. Hepatic bisegmentectomies 7-8 (with ligature of the right hepatic vein) were thought to be possible only in the presence of an accessory (posterior or posteroinferior) right hepatic vein,[17] but recently Machado et al.[18] have published the feasibility of this technique in four consecutive cases in the absence of a large inferior right hepatic vein and without venous reconstruction.

The middle and left hepatic veins form a common trunk in the majority of cases. After examination of 140 specimens Onishi et al.[19] found a common trunk in 88.5% and independent trunks in 11.5% of the specimens, almost the same proportion found by Nakamura and Tsuzuki [13] (84.3%). The length of the common trunk was 0.2 to 1.5 cm (mean: 0.78 cm), whereas Nakamura and Tsuzuki reported 0.2 to 1.7 cm, with those having a length of 1 cm or longer comprising 31.5% of the specimens. The confluence pattern of the middle hepatic vein was also investigated,[19] and eight major types were recognized (**Figure 8**). In addition, small individual veins, draining segment 3 or the superior part of segment 4 (Segment 4a), may empty directly into the suprahepatic inferior vena cava close to the main left hepatic trunk, a feature usually absent on the right side.[13] The intersegmental area between segment 4 and the left lateral segment forms a watershed between the drainage territories of the middle and left hepatic veins. This is drained in more than 60% of livers by a tributary of the left hepatic vein that run across the falciform ligament, and in up to 30% of cases equally between tributaries of the left and the middle veins. In less than 10% the entire segment 3 is drained by its vein,

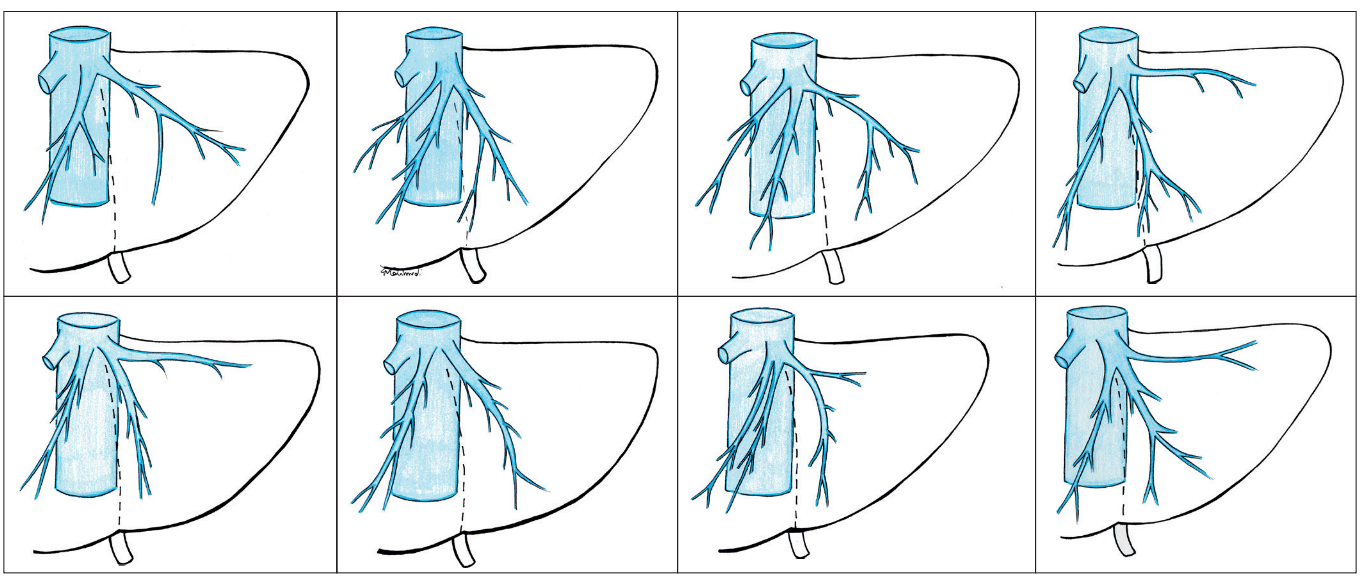

Figure 8. Anatomical variations of the left and middle hepatic veins (8 major types), according to Onishi et al.[19] Note that in most of cases the left hemiliver is drained by a common trunk. Only the trunk of the right hepatic vein is shown on the schemas.

which joins the middle hepatic vein instead of uniting with the segment 2 vein.[13] Concerning the left hepatic vein itself, Reichert et al.[20] found three distinct anatomical variants. The most common variant, observed in 73% of specimens, was a union of segment 2 and 3 veins to form a principal left hepatic vein at the umbilical fissure. Notably, this variant would receive significant tributaries draining the posterior aspects of segment 4 as it approached the inferior vena cava. The second most commonly (14%) observed pattern was separate large veins, each draining an individual segment that united to form the left hepatic vein at the level of the inferior vena cava. In this pattern, each venous channel received tributaries from the posterior aspects of segment 4 before uniting just before the inferior vena cava. The third anatomical variant, identified in 13% of specimens, was a union of segment 2 and 3 draining veins in the parenchyma of the graft to form the left hepatic vein medial to the umbilical fissure. In this variant, the left hepatic vein is a large single vessel that directly empties into the inferior vena cava without receiving significant tributaries from segment 4.

Although the liver segments based on the position of rigid planes along vascular main stems are well described by Couinaud [6], the volume, position, and shape of venous segments are barely understood. Masselot and Leborgne [16] and Gupta and Gupta [21] characterized the principle drainage area of the hepatic veins. According to their work, the left liver vein drains the left lateral sector (segments 2 and 3) in up to 95% of all analyzed livers. Besides draining segments 4 and 5, the middle hepatic vein is also described as essential in creating overlapping drainage areas and, thereby, forming functional anastomosis between the left and right hepatic vein. The right liver vein with its two main branches predominantly drains segments 6 and 7. In general, both describe the right hepatic vein as the largest venous system within the human liver.[16,21]

Using three-dimensional images based on CT/MRI scan to obtain accurate volumetric data and a better anatomical understanding, Fischer et al.[11] were able to identify three venous segments and six venous subsegments, which they have compared with the Couinaud segmental approach. They found that the left hepatic vein drains the smallest part of the liver with 20.4% of total liver volume. The middle hepatic vein has a drainage area of 32.5%, and the right hepatic vein drains 47.1% of the total liver volume. They showed that segments 2 and 3 are positioned only within the left hepatic vein area of drainage, that segments 4a and 4b are covered by the drainage area of the left (40.3%, 39.8%) and middle (53.6%, 50.3%) hepatic veins. For segment 5 there is a distribution between the area of the middle (42.5%) and right (54.5%) hepatic veins. In contrast, segments 6 (99.1%) and 7 (99.8%) are only within the drainage area of the right hepatic vein. Segment 8 shows a 53.6% drainage by the middle hepatic vein and 45.4% drainage by the right hepatic vein.

Although the findings outlined above represent the most common anatomical pattern, there are a great number of inter-individual differences in the drainage pattern of the liver, in terms of which of these veins or tributaries are the dominant drainage veins of the respective segments. It is generally acknowledged that there is overlapping between these venous drainage territories, and that interruption of the tributaries of a single vein does not result in serious congestion, probably because of the development of preexisting venous collaterals.[16,22]

The relative position of the hepatic vein and Glissonean pedicles differs depending upon their location in the liver. In the upper part of the liver, almost all branches of the Glissonean pedicle tree intersect those of the hepatic vein, while in the lower part of the liver almost all branches of the Glissonean pedicle tree tend to run parallel to the hepatic vein (**Figure 9**).[23]

The suprahepatic IVC and extrahepatic segments of the major hepatic veins can be exposed by completely freeing the liver from its attachments and the retrohepatic IVC. Freeing the liver from the retrohepatic IVC is completed by dividing the short hepatic veins and the IVC ligament, also called “Makuuchi’s ligament”.

Another key anatomical point is the inferior phrenic veins. Both the right and left inferior phrenic veins flow into

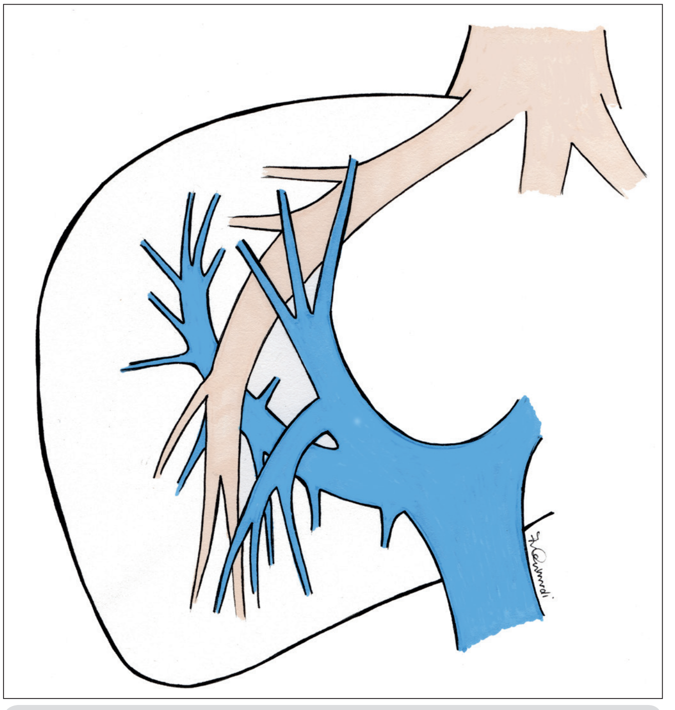

Figure 9. Relationship between Glissonean pedicles and right hepatic vein. Note that on superior segments (7 and 8) of the liver most of Glissonean pedicles run perpendicularly to right hepatic venous branches. Contrarily, on inferior segments (5 and 6) Glissonean and hepatic venous branches run more parallel.

the right hepatic veins and the common trunk at their most cranial points, respectively. Therefore, the division veins and subsequent dissection of the more proximal connective tissue becomes an important procedure in fully exposing the right hepatic vein or the common trunk and facilitating extensive clamping of these veins. This procedure becomes particularly important for left-sided grafts in living-donor liver transplantation, because the extrahepatic portion of the hepatic vein is shorter than in right hemiliver grafts.

PORTAL VEIN

The portal vein divides at the hepatic hilum into right and left pedicles, on which the right and the left lobes of the liver are respectively based. A theoretical plane, the main portal fissure, separates the two lobes. The right portal vein, the shorter of the two, lies anterior to the caudate process and enters the liver through the hilar plate to divide into anterior and posterior branches (**Figure 10A**). The anterior branch curves forward, lies in a vertical plane, and divides into ascending and descending branches for segments 8 and 5 respectively. The posterior branch curves posterolaterally, lying in a horizontal plane and then superiorly in an arch-like pattern, giving branches to segments 6 and 7, or the posterior branch divides in two main branches, similarly to anterior portal branch, for segments 6 and 7.[15] The left portal vein is much longer than the right and its course consists of two parts: a transverse part 3-5 cm long in the hilum, and a part that curves anteriorly and to the left as an arch towards the base of the umbilical fissure where it is joined anteriorly by the round ligament. The anatomy of the left portal venous system is remarkably constant. The segment 2 vein is usually solitary, whereas segment 3 can have up to three veins.[15] The arch then curves forward and distributes a varying number of ascending and descending branches to segment 4, which lies between the falciform ligament and the main portal fissure. The caudate lobe is most commonly vascularized by the left branch of the portal vein and only occasionally by the right.[14] The right portal vein has more variations (**Figure 10**). A trifurcation of the main portal vein occurs in 10-15% of cases, where the right portal vein immediately divides into two sectorial branches (**Figure 10B**). Occasionally one of the sectorial veins, usually the one supplying the right anterior segments 5 and 8, comes from the left portal vein in a short distance after its origin (**Figure 10C**). A third variation is the caudal shift of the right posterior segments resulting in the right posterior portal vein arising directly from the main portal trunk, before its bifurcation (**Figure 10D**). In all of these circumstances the transverse portion of the left portal vein is usually shorter than normal. Finally, the left portal vein may rarely be absent. In such cases, the main portal trunk is undivided as it enters the liver, gives off its right segmental branches and then turns left, crossing the umbilical fissure intraparenchymally as the left portal vein and then supplies branches to the left lobe segments.[24] Chaib et al.[25] found that the portal vein trunk been divided into right and left branches in 98.3% of specimens, a median branch appeared in 15.2%, and no bifurcation of the portal vein occurred in 1.6%. Concerning living donor liver transplantation, one key to obtaining sufficient length and mobility of the graft portal vein is to divide portal tributaries to the caudate lobe (segment 1). Although some researchers insist that this necessitates the resection of segment 1, it can be left intact with no adverse effect in the absence of afferent bloody supply.[26]

Some researchers have reported that portal branches to segment 4 originating from the right portal trunk are not uncommon, and have insisted that care must be taken to preserve the viability of segment 4 during donor hepatectomy;[22] however, many authors believe this is based on a misinterpretation of angiographic images.[19,26] Onishi et al.[19] investigated the ramification patterns of portal branches to segment 4 in a total of 166 specimens. Portal vein branches to segment 4b were observed to branch from the right angle and upper portion of the right border of the umbilical portion of the portal vein in every specimen, and one or two branches were given off by the inferior portion of the right border by the transverse portion of the vein in only five specimens. There were three to six branches in every specimen; in the

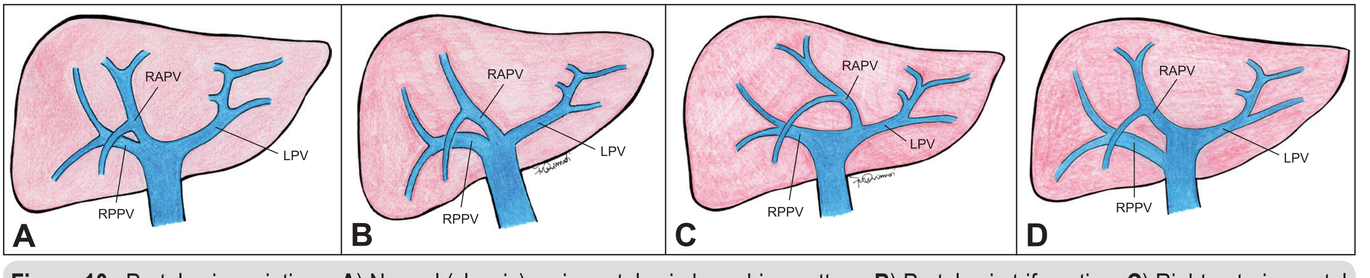

Figure 10. Portal vein variations. **A**) Normal (classic) main portal vein branching pattern. **B**) Portal vein trifurcation. **C**) Right anterior portal vein as a branch of the left portal vein. **D**) Right posterior portal vein as the first branch of the main portal vein. RPPV: Right posterior portal vein; RAPV: Right anterior portal vein; LPV: Left portal vein.

overwhelming majority of specimens, there was one large (> 2 mm in thickness) and two or three small branches (< 2 mm in thickness) (41% of specimens) or two large and one or two small branches (35.6% of specimens). Portal vein variations in the superior area of the medial segment (segment 4a) showed almost all of the portal branches to segment 4a branching lower than those for segment 4b posteriorly to the umbilical portion on the left portal vein. Portal branches to segment 4b consisted most of the time of one large and one (or no) small branch (57.8%) or two large and no small branches (29%).

It is well known that the pattern of intrahepatic vessel ramification in the right posterior hepatic sector varies considerably.[5–7] According to Kinoshita et al.[27] simple bifurcation of the posterior sectorial trunk occurred in only 37.6% of their 202 portography cases. Couinaud [28] (1989) reported that the most common type of ramification (63.1%) is an arch-like pattern in which a thick posterior sectorial trunk issues several branches in succession at almost equal intervals, which supply segments 6 and 7. Hata et al.[29] classified the portal ramification patterns of the posterior sector of the liver into four groups (**Figure 11**): 1) the arch-like group (32%), showing plurality of portal branches to segment 6; in this group the posterior sectorial trunk showed a curved course upward and backward without a sudden change or turn in direction, thus the branch for segment 7 looked like a direct continuation of the posterior sectorial trunk; 2) the simple bifurcation group (27.9%), in which the posterior sectorial trunk simply divided into two branches for segments 6 and 7; 3) the trifurcation group (6.6%), which was characterized by an intermediate branch that supplied a territory between segments 6 and 7; notably, the intermediate branch originated from the wedge-shape region between the two main branches of the posterior sectorial trunk; and 4) variations involving the anterior segmental branches (33.5%), where the most common variation was a trifurcation of the right portal vein into P6 (portal vein to segment 6), P7, and the anterior sectorial trunk. They also found P5 and P6 issued from a common trunk (3.5%), and in only one specimen the right portal trunk and the posterior

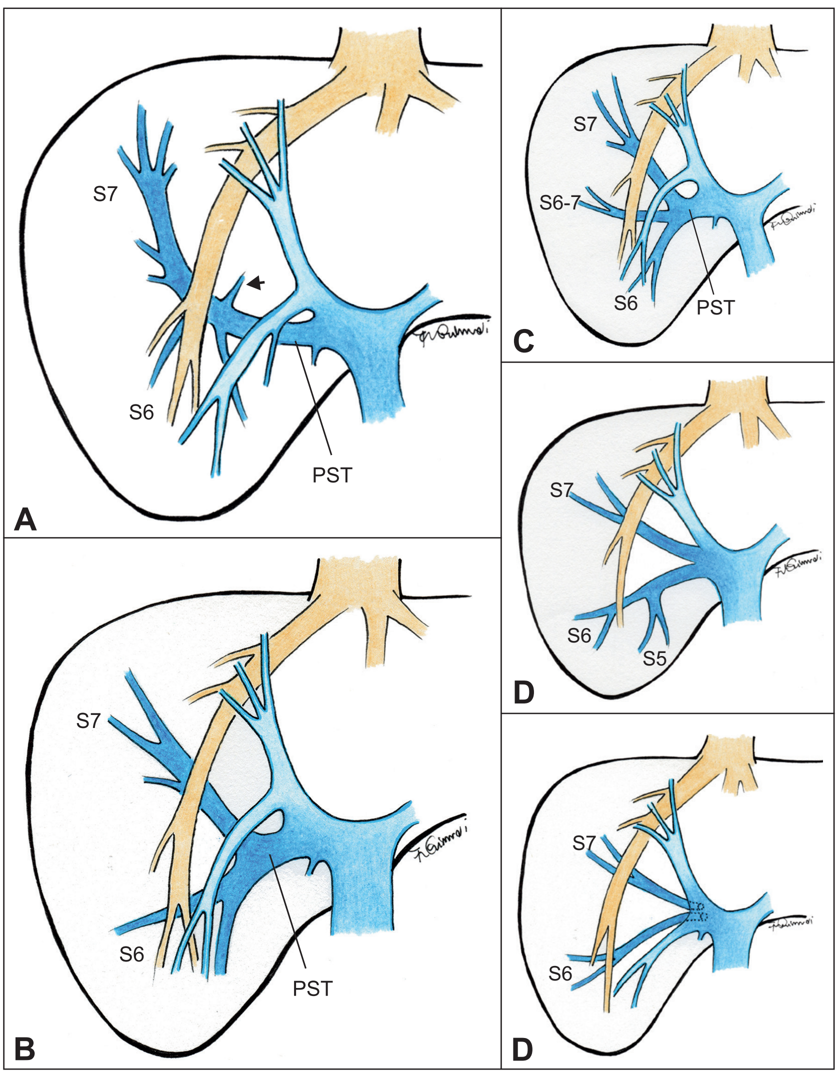

Figure 11. Portal vein patterns of branches from the right posterior sector. **A**) Arch-like ramification of the posterior sectorial trunk (PST), present in nearly 32% of cases. Arrowhead: upward branch for paracaval region of segment 7. **B**) Bifurcation of the posterior sectorial trunk, present in nearly 28% of cases. Figures C, D and E represent examples of less common distribution of right portal branches. **C**) Intermediate branch between those for segment 6 and 7. **D**) Branches to segment 5 and 6 share a common trunk in the absence of anterior sectorial trunk. **E**) Absence of PST, branches to segment 6 and to segment 7 originate separately from the right portal vein. PST: Posterior sectorial trunk. (Adapted from Hata et al.[29])

sectorial trunk were absent, with the left portal vein, the anterior sectorial trunk, P6, and P7 arising simultaneously from the porta hepatis.

Using computed tomography during arterial portography, Cho et al.[30] concluded that the right anterior portal vein did not bifurcate into P8 and P5, but into a ventral and a dorsal branch, which were approximately equal in size. Based on these findings, they have proposed a new classification for the liver anatomy, in which the right liver is divided longitudinally along the anterior fissure of the right liver, demarcated by the anterior fissure vein.[12,30]

These apparent discrepancies with Couinaud's scheme have been very recently discussed in an interesting way by Fasel et al.[10], where they performed helical CT scans of 25 portal veins showing that the number of branches originating from the right and left portal vein was never eight, but in fact many more (mean 20, ranging from 9 to 44). The differences seen between Couinaud's system and others may be simply the result of gathering (or not gathering) various branches of the same order to one territory for the sake of obtaining a rigid number of segments, while the underlying reality does not differ.

ARTERIAL ANATOMY

The common hepatic artery, a branch of the celiac trunk, but occasionally of the superior mesenteric pedicle, supplies the liver with arterial blood through its right and left hepatic branches (**Figure 12**). However, the origins of these two vessels are subject to considerable variation, the most common being a left hepatic branch from the left gastric artery and a right hepatic branch from the superior mesenteric artery (**Figure 12**).[31] Under variant patterns, the lobes may receive blood supply from the superior mesenteric artery, left gastric artery, aorta, or other visceral branches. These vessels may be accessory, occurring in addition to the normal arterial supply, or replaced, representing the primary arterial supply to the lobe. The common hepatic artery may divide into its terminal branches anywhere between its origin and the hilum of the liver. The division usually takes place to the left of the hilum, resulting in a slightly longer right artery.[15] The right hepatic artery then courses laterally, posterior to the common bile duct and right hepatic duct, and enters the liver parenchyma. The left hepatic artery courses along the

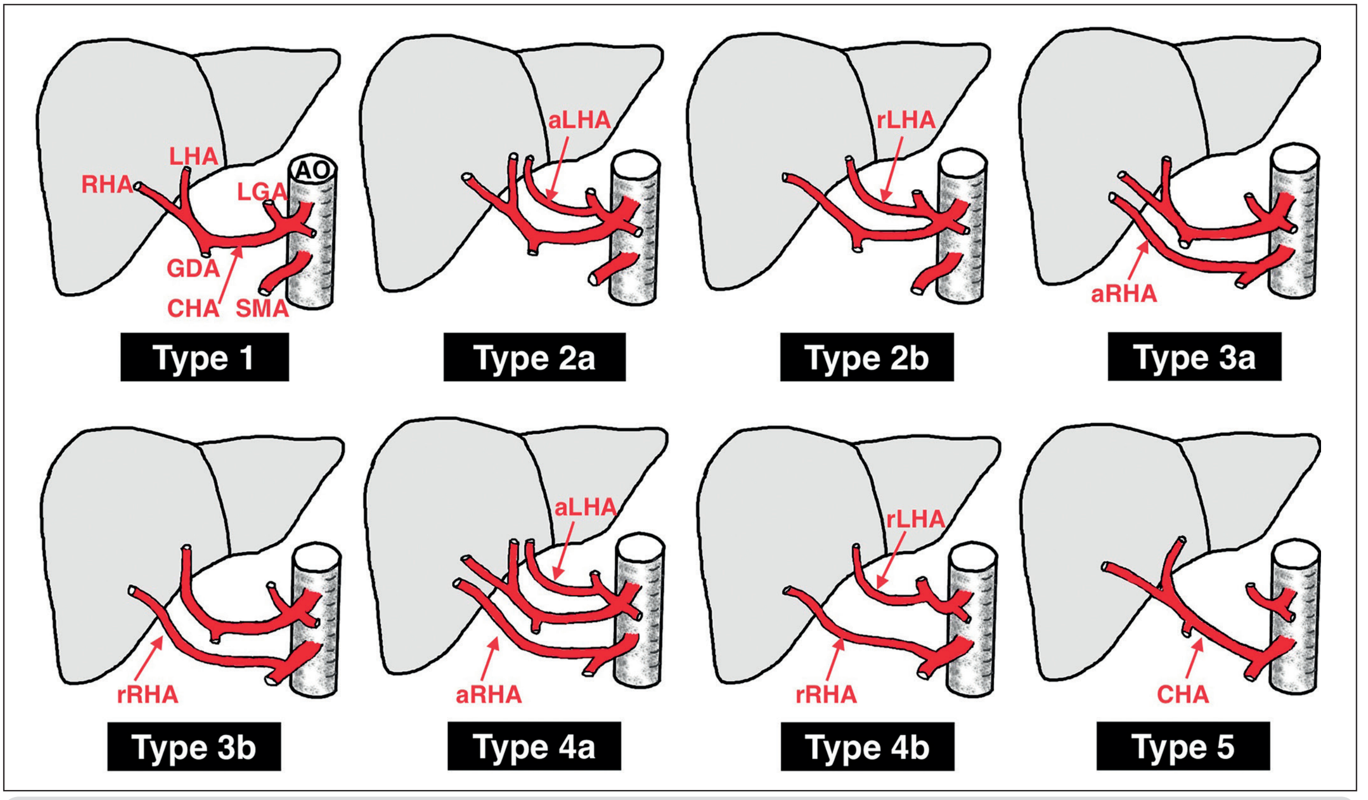

Figure 12. Hepatic artery anatomy variations. **Type 1** – standard presentation; **Type 2** – an accessory or replaced left hepatic artery from left gastric artery; **Type 3** – an accessory or replaced right hepatic artery from superior mesenteric artery (SMA); **Type 4** – both right and left hepatic arteries arising from the superior mesenteric and left gastric arteries, respectively; **Type 5 -** common hepatic artery from SMA; **Type 6** (not shown) – common hepatic artery originating directly from the aorta. RHA: right hepatic artery; LHA: left hepatic artery; LGA: left gastric artery; GDA: gastroduodenal artery; CHA: common hepatic artery; SMA: superior mesenteric artery; aLHA: accessory left hepatic artery; rLHA: replaced left hepatic artery; aRHA: accessory right hepatic artery; rRHA: replaced right hepatic artery. (Adapted from Hiatt et al.[33])

inferior aspect of the lobe, with the left hepatic duct and left portal vein, for a varying distance before entering the left lobe at the level of the umbilical fissure.

The anomalies of the arterial system rival those of the biliary tract but, unlike biliary anomalies, they are important in both segmental and whole liver transplantation. Extrahepatic anomalies are recognized readily at standard multiorgan retrieval, and arterial reconstruction is a relatively routine procedure although it increases the likelihood of complications. Arterial anomalies in the donor and recipient may occur and influence graft implantation. Modifications of the dominant scheme, in which the liver receives its total inflow from the hepatic branch of the celiac axis, occur in 25-75% of cases.[32]

Hiatt et al.[33] analyzed the records of 1,000 patients who underwent liver harvesting for orthotopic transplantation and could classify arterial variations as one of six types (**Figure 12**): Type 1 (75.7%), the normal pattern in which the common hepatic artery arose from the celiac axis to form the gastroduodenal and proper hepatic arteries; the proper hepatic artery divided distally into right and left branches; Type 2 (9.7%), in which a replaced or accessory left hepatic artery arose from the left gastric artery; Type 3 (10.6%), in which a replaced or accessory right hepatic artery originated from the superior mesenteric artery; Type 4 (2.3%), a double-replaced pattern in which the right hepatic artery arose from the superior mesenteric artery and the left hepatic artery was a branch of the left gastric artery; Type 5 (1.5%), in which the entire common hepatic artery originated as a branch of the superior mesenteric artery; and Type 6 (0.2%), in which the common hepatic artery took direct origin from the aorta.

BILE DUCTS

Although consequential anomalies of the bile ducts are much more common than those of the portal vein, they less frequently necessitate surgical modifications. So many variations of the biliary tree exist that the "normal" anatomy is present in only about 50% of people [34] (**Figure 13**). Usually, a short vertical right hepatic duct and a longer horizontal left hepatic duct join at the hilum to form the common hepatic duct. The right duct is formed by the fusion of the right anterior and posterior sectorial ducts at a variable point in its intrahepatic course. These individual ducts, in turn, course along the vascular pedicles, draining the anterior (5 and 8) and posterior (6 and 7) segments of the right lobe of the liver. The left duct is formed by fusion of segment 2 and 3 ducts. The segment 4 duct is more variable, but most commonly drains into the left hepatic duct. The biliary confluence is separated from the posterior aspect of the quadrate lobe of the liver by the hilar plate, which is the fusion of connective tissue enclosing the biliary and vascular elements with Glisson's capsule (**Figure 14**).[35] Because of the absence of any vascular interposition, it is possible to open the connective tissue constituting the hilar plate at the inferior border of the quadrate lobe and by elevating it to display the biliary convergence and left hepatic duct.

Knowledge of the blood supply of the extrahepatic biliary apparatus is important when performing hilar dissections. The epicholedochal plexus receives its blood supply from three arterial branches [4,34]: a branch of the posterior superior pancreatoduodenal artery, a branch of the right hepatic artery arising at the point where it passes behind the common bile duct, and a branch running caudally from the arteries of the hepatic hilum. Although these branches usually communicate with each other, division of any one of them may occasionally result in severe bile duct ischemia. Approximately 60% of the vessels that supply the supraduodenal duct run upwards from the gastroduodenal arcade below, while 38% run down, mainly from the hepatic artery. The remaining 2% have a non-axial supply arising from the common hepatic artery.

Couinaud [6] has classified biliary anatomy variations into six main types **(Figure 13)**. In Type A (57%), the anatomy is normal. In Type B (12%), there is a trifurcation of the common bile duct into right anterior, right posterior, and

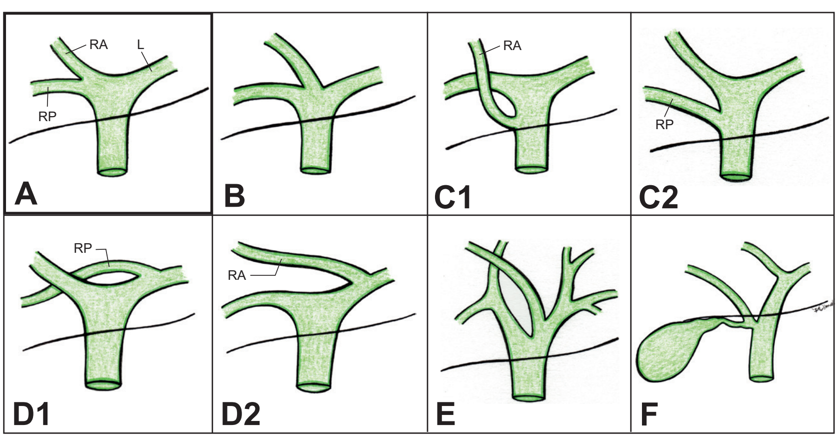

Figure 13. Main variations of the hepatic biliary duct confluence. **A**) Typical anatomy of the confluence. **B**) Triple confluence. **C**) Ectopic drainage of a right sectorial duct into the common hepatic duct (C1, right anterior duct draining into the common hepatic duct; (C2, right posterior duct draining into the common hepatic duct. **D**) Ectopic drainage of a right sectorial duct into the left hepatic ductal system (D1, right posterior sectorial duct draining into the left hepatic system). **E**) Absence of the hepatic duct confluence. **F**) Absence of right hepatic duct and ectopic drainage of the right posterior duct into the cystic duct. RP: right posterior duct; RA: right anterior duct; L: left duct.

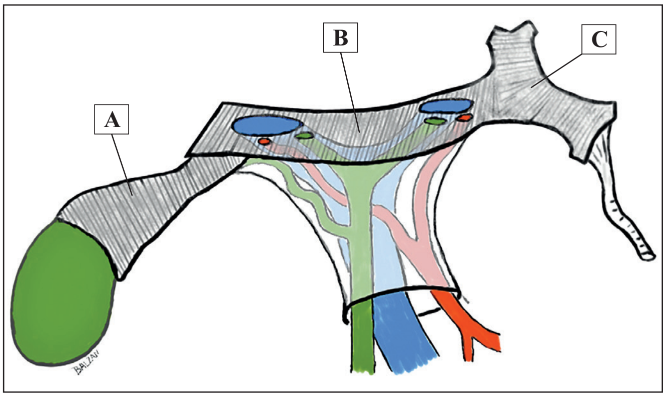

Figure 14. Sketch of the anatomy of the plate system. The cystic plate (**A**) above the gallbladder, the hilar plate (**B**) above the biliary confluence and at the base of the quadrate lobe, and the umbilical plate (**C**) above the umbilical portion of the portal vein.

the left hepatic duct, with an absence of a demonstrable length of the right hepatic duct. In Type C (20%), there is an aberrant drainage of the right segmental ducts into the common hepatic duct. In Type D (6%), there is an aberrant drainage of the right segmental ducts into the left hepatic duct. The right posterior duct is more commonly aberrant than the right anterior duct in both Type C and Type D. In Type E (3%), there is absence of hepatic duct confluence, there being convergence of two more ducts from either lobe to form the common hepatic duct. Finally, in Type F (2%), there is an absence of the right hepatic duct with ectopic drainage of right posterior duct into the cystic duct.

Concerned about the relatively high incidence of biliary complications in reduced-organ liver transplantations, Reichert et al.[20] found four distinct patterns of left bile duct anatomy. The most common pattern was the union of segment 2 and 3 ducts to form the left lateral segment duct close to the umbilical fissure. The incidence of this pattern was 55%. The union of segment 2 and 3 ducts was at the umbilical fissure in 5% of specimens, to the right of the umbilical fissure in 50% of specimens, and to the left of the umbilical fissure in 45% of specimens with this specific anatomical pattern. The left lateral segment duct was then joined by a single segment 4 duct between the umbilical fissure and the hilum to form the left hepatic duct. The second most common (30%) anatomical pattern was creation of the left lateral segment duct close to the umbilical fissure with two parallel ducts from segment 4 joining to form the left hepatic duct. Typically, one segment 4 duct is on the umbilical portion of the left portal vein, and one is close to the union of the right hepatic duct. The third biliary pattern (10%) identified was a single segment 3 duct that receives the duct from segment 4 and joins segment 2 close to the hilum. In this variant, a left lateral segment duct was absent. The fourth pattern (5%) was defined by segment 2 and 3 ducts joining immediately to the right of the umbilical fissure to form a short left lateral segment duct that receives the segment 4 duct just after crossing the umbilical fissure to form the left hepatic duct. Notably, in 10% of specimens, at least one distinct duct from the right liver was observed to cross Cantlie's line and join the left duct system.

Ohkubo et al.[36] classified the confluence patterns of the right intrahepatic bile ducts into three patterns according to the anatomic relation between the right posterior sectional bile duct and the portal vein (**Figure 15**): supraportal pattern (82.7%), in which the right posterior sectional bile duct ran dorsally and cranially to the right of the right anterior portal vein and joined with the distal bile duct at its cranial side; infraportal pattern (11.8%), in which the right posterior sectional bile duct ran ventrally and caudally to the right or the right anterior portal vein and drained into the distal bile duct at its caudal side; and a combined pattern (5.5%), in which some parts of the right posterior sectional bile duct entered the distal bile duct supraportally and the remaining parts of the right posterior sectional bile duct joined with the distal bile duct infraportally.

SEGMENT 1 (CAUDATE LOBE)

Analysis of anatomy, comparative anatomy, and embryology of the liver led to recognition of the modern hepatic or Couinaud segments, with the Spiegel lobe designated as an independent hepatic segment, termed the dorsal sector, caudate lobe, or Couinaud segment 1. The lobe was described as containing two (left and right) or three subsegments (the left or Spiegel lobe, the medial paracaval portion, and the right portion or caudate process).[37] Couinaud and other investigators [38,39] have reported that the right caudate

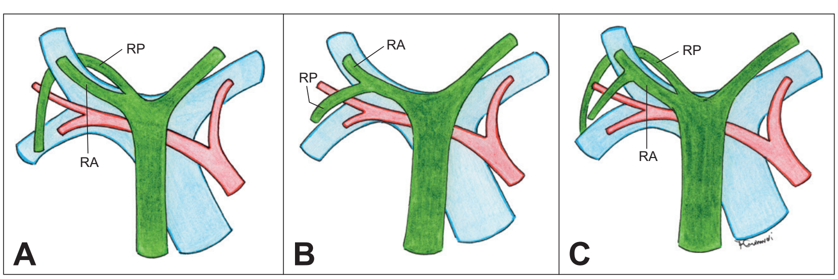

Figure 15. Anatomic relationship of the right posterior sector bile ducts with the right portal vein **A**) supraportal, **B**) infraportal, and **C**) combined pattern. RP: right posterior bile duct; RA: right anterior bile duct.

represents the separate segment 9. Confusion regarding terminology arises from the proximity of the caudate lobe to the portal confluence, proximal hepatic arteries, and the main hepatic veins-vena cava confluence.

The caudate lobe or dorsal liver sector, with its intimate and extended contact with the inferior vena cava, is independent of the two hemilivers from a functional point of view. It is the mid portion of the posterior liver (**Figure 16**). It lies between the main liver and the anterior surface of the inferior vena cava (below the entrance of the main hepatic veins into the vena cava and behind the transverse portal arch). Anteriorly, the dorsal sector or caudate lobe is connected (from left to right) to segments 4, 8, and 7; the limit is represented by a quadro-dorsal (i.e., quadro-caudal) and a dorso-paramedian fissure, and is difficult to identify (**Figure 16**).[39] Rarely, the caudate lobe completely encircles the vena cava (**Figure 16**).

The Spiegel lobe is the most readily identified portion of segment 1 (**Figure 16**). It is protuberant and can be seen through the gastrohepatic ligament to the left of the vena cava. Three major structures surround the Spiegel lobe: to the right, the anterior lateral aspect of the vena cava; anteriorly, the left main portal pedicle; and superiorly, the left hepatic vein. The true division, or intersegmental plane, between the Spiegel lobe and the paracaval portion is defined by the first- or second-order segmentation of the portal branches near the left edge of the vena cava, as described by Kogure and collegues.[40] An external notch is evident at the caudal edge of the caudate lobe in 54% of examined livers.[40] A dominant portal branch (up to 2 mm) from the right may cross this plane (the intersegmental plane) to the Spiegel lobe on the left, and the proper hepatic vein consistently is found deep in the intersegmental plane. Division of the parenchyma of the caudate lobe is performed best along the sagittal plane toward the left margin, not through the middle point, of the vena cava.[41]

The left border of the paracaval portion is defined as the intersegmental plane near the left margin of the vena cava. The posterior border is the vena cava, and the anterior border is the main right portal pedicle at its caudal aspect, although the parenchyma merges with segments 4 and 8, and sometimes 7, at the confluence of the main hepatic veins with the vena cava. Because the right and anterior margins of the right portion of posterior sector are incorporated completely into the posterior surface of the right liver, the precise right margin of the caudate process is obscure. Kitagawa et al.[42] reported a careful analysis of 55 cadaveric dissections, where they defined the right paracaval plane as a reference for the position of the right border of the caudate process. The plane is marked by three landmarks: (i) the bifurcation of the right portal vein, (ii) the end of the right hepatic vein, and (iii) the notch in the gallbladder fossa. In 80% of livers, the caudate extended no more than 1 cm to the right of the right paracaval plane, and never extended more than 3 cm to the right of this landmark. The caudate process never touched the right hepatic vein (except at its confluence with the vena cava). This finding reveals that a significant mass of the right hemiliver can be preserved with the right hepatic vein pedicle when complete caudate resection is required without concomitant right hepatectomy. The ventral or anterior margin is more difficult to define. Kwon et al.[43] described the ventral margin as a horizontal curvilinear plane that is defined by the hilar plate and *ligamentum venosum*; however, Couinaud's

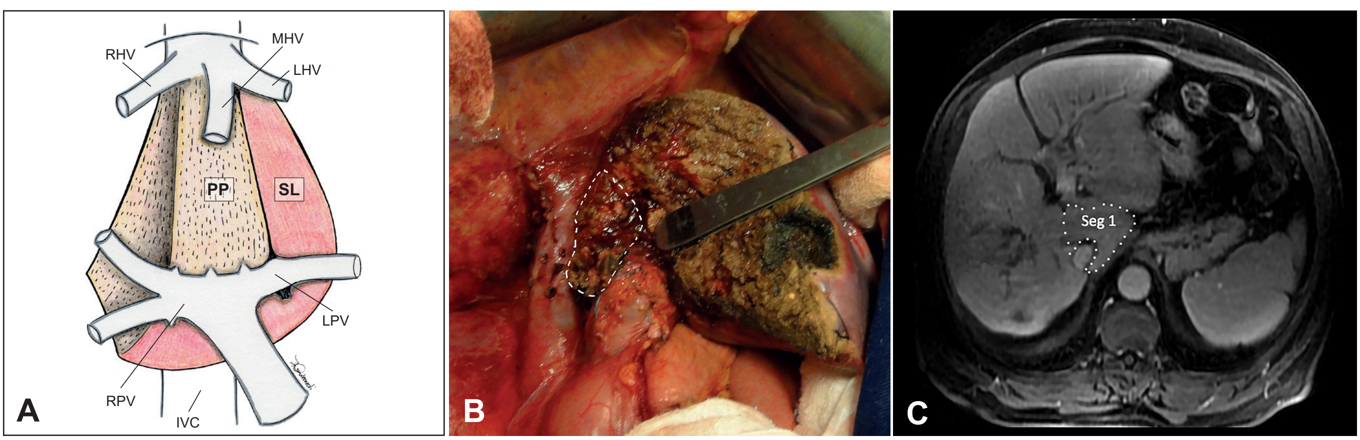

Figure 16. The caudate lobe lies between the hilar structures and the vena cava. It has a roughly pyramidal form. The Spiegel lobe corresponds to the portion on the left of the inferior vena cava. Note the lack of a defined border between the right border and the anterior border of the caudate process with the main right liver. **A**) Schematic representation. **B**) Surgical aspect showing the right paracaval plane of segment 1 (Dashed area). The right hemiliver was resected and the segment 1 visualized between the portal bifurcation and retrohepatic vena cava. **C**) Magnetic resonance imaging showing hepatic segment 1 (dashed area) encircling the retro-hepatic vena cava. RPV: right portal vein; LPV: left portal vein; RHV: right hepatic vein; MHV: middle hepatic vein; LHV: left hepatic vein; IVC: inferior vena cava; SL: Spiegel lobe; PP: paracaval portion.

use of the plane of the middle and right hepatic vein as a guide is equally helpful and simpler. Kwon et al.[43] found that the caudate interdigitated between the origins of the three main hepatic veins and abutted the diaphragm in nearly 50% of studied cadavers. Small branches to each major hepatic vein required meticulous attention to avoid injury to the main veins. Makuuchi et al.[44] and Takayama et al.[45] described a counterstaining technique in which dye is injected into the portal venous branches to aid in identification of the otherwise undefined border of the right caudate and the right lobe.

The caudate lobe is drained predominantly on the left by a single vein in 50% of livers and by two or three veins in the rest. In addition, there may be up to 20 small short venules attaching the caudate lobe to the retrohepatic inferior vena cava.[46] Heloury et al.[47] also described small veins that directly enter the left and middle hepatic veins. The network of hepatic veins communicates within the caudate lobe to form a rich anastomosis between the main hepatic veins and vena cava within the lobe. Usually there are three major veins at most,[47,48] a few intermediated-sized veins, and anywhere from nine to more than 30 tiny accessory branches. The largest vein usually drains anterolaterally into the vena cava from the caudate process (a single proper vein in up to 88%).[40] The Spiegel lobe is usually drained by one large and a few accessory veins and rarely is drained only by several small veins. The paracaval portion is drained by three groups of veins: a large-sized group, a middle-sized group (mainly right-side drainage), and a group of thread-like veins (caudal drainage). The caudate process has the most variable anatomy, but rarely has larger veins and usually has only small accessory veins.[40] The middle anterior surface of the vena cava is generally lacking of any branches from the caudate lobe. Surgeons use this anatomic constancy when using an anterior parenchymal transection approach to major resections (**Figure 17**).[49–51]

An average of three (one to six) portal branches supply the entire caudate [40,41] and may arise from the left, right, bifurcation, or a combination of the portal branches. Although the vessels to the left supply the caudate, the deeper veins on the right, which ascend above the plane of the hepatic vein, may supply the posterior portion of segment 4 or 8. The pedicles supplying the left and right portions of the caudate [48] and a third pedicle [47] have been described, but surgical experience and Couinaud's comparative analysis of liver casts have shown that the high variation prevents precise definition of pedicles.[41]

The distribution of hepatic arterial branches to the caudate lobe is highly variable. The caudate lobe and caudate process receive separate branches from the right and left hepatic arteries in what has been described as an "arcade" or "tree" pattern.[52] Resection of the lobe along Glisson's sheaths [53] minimizes the need to describe every known variation, because all variations occur beneath the hilar plates and because when the vein, artery, and duct join together, a sheath arises from the transverse portal arch and enters the dorsal sector.[54]After the hilar plate is lowered, dissection permits identification of branches, ligation under direct vision, and avoidance of bleeding and bile leaks.[53] The left branches are more constant, and the right branches are more variable and more often are absent.[41]

Caudate bile ducts are also variable.[55] The dominant left branch often is recognized at surgery. Branches to the hilum or right branches occur frequently and may arise from the posterior-superior surface of the portal arch, superficially, or deeply within the lobe. By lowering the hilar plate or by approaching the inflow through the umbilical fissure, identification of the often-dominant biliary radical to the left caudate can be visualized and ligated.[41] Because biliary drainage from the caudate lobe can flow into the right duct, left duct, or hepatic bifurcation, cancer of the hilar bile duct

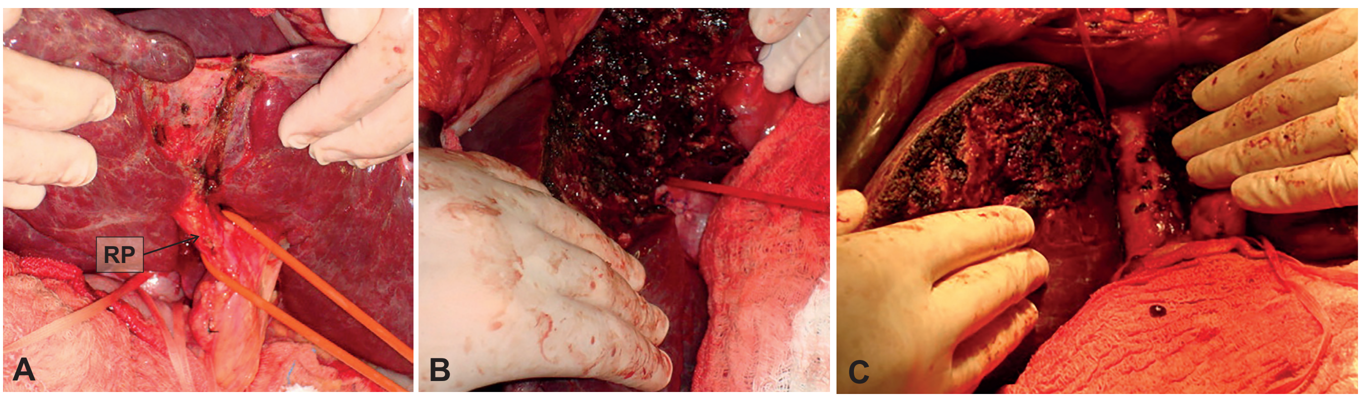

Figure 17. Surgical aspect during liver resections using anterior approach. **A**) Vascular control before the anterior approach for a right hepatectomy due to a large HCC. The right Glissonean pedicle is encircled. **B**) Note the umbilical tape, which runs between the posterior aspect of the liver and the inferior vena cava (IVC), representing the so-called "hanging maneuver". **C**) View after parenchyma transection, the anterior surface of the IVC is completely exposed. RP, right Glissonean pedicle.

can extend into the lobe regardless of its invasion of the left or right main branch of the bile duct.

TERMINOLOGY FOR HEPATIC RESECTIONS

According to the hepatotomy plan, liver resections can be anatomically based or not. Three or more anatomic segments resected (contiguous or not) should be designated a major hepatectomy while minor ones are those with less than three anatomical segments resected including wedge resections.

As a surrogate of the functional hepatic reserve, the resected liver volume and mainly the estimated remnant liver volume should be reported (see **Chapter 4** - Underlying Liver Disorders in Hepatic Surgery - and **Chapter 5** - Liver Function Assessment Before and After Hepatic Resection). Also, in order to make a fair comparison among series and estimate the morbidity and mortality associated with the liver surgery, every associated procedure (resections of other organs, vascular and/or biliary reconstruction, use of combined ablative methods) should be described.

In an attempt to standardize the terminology of liver resections, the Brisbane 2000 Terminology of Hepatic Anatomy and Resection [56] divided the liver into eight segments and four sections: the right anterior section (segments 5 and 8), right posterior section (segments 6 and 7), left medial section (segment 4), and left lateral section (segments 2 and 3). Some of the multiple possibilities of resection and proper terminology can be seen in **Figure 18.** Of course segmentectomies, isolated or combined - contiguous or not – are also possible, and should be reported according to segment number (segment is indicated in short form as "Sg" followed by the corresponding Couinaud segment number).

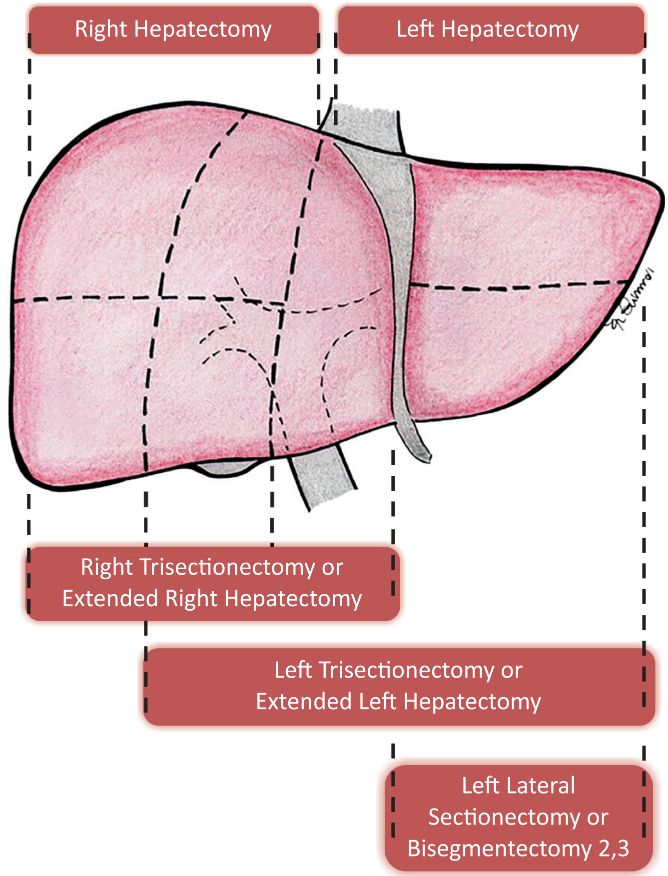

Figure 18. Examples of liver resections using the IHPBA (International Hepato-Pancreato-Biliary Association) 2000 Brisbane terminology of liver resections. The resection of the caudate lobe should be reported whenever done. (Adapted from Strasberg et al.[56])

In fact, it is always correct to refer to any resection by its segments; e.g., for a resection of Couinaud segments 5 to 8, the terms "right hepatectomy" and "resection Sgs 5-8" are equally acceptable.

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