Chapter 3

Liver Anatomy

Primary Author

Victoria Chernyak Montefiore Medical Center

Contributing Authors

Kathryn J. Fowler UC San Diego
Claude B. Sirlin UC San Diego

Illustrators & figure contributors

Victoria Chernyak Montefiore Medical Center
Claude B. Sirlin UC San Diego

Editors

Victoria Chernyak Montefiore Medical Center
Claude B. Sirlin UC San Diego

Table of Contents

Liver Anatomy

Background

Assessment of vascular and biliary anatomy and presence of anatomic variants may be important for interventional or surgical planning.

Evaluation of hepatic volume can be helpful in estimating functional liver reserve, selecting an appropriate treatment, and determining the prognosis.

- Liver volumes vary between patients and are related to patient body surface area and weight.
- Average liver volume in healthy patients is 1,225 cm^3 (±217).
- As cirrhosis progresses, segmental atrophy leads to decrease in liver volume. Mean liver volumes are 1,100 cm^3 (±337) in Child-Pugh class A, 1,040 cm^3 (±365) in Child-Pugh class B, and 800 cm^3 (±205) in Child-Pugh class C.

Sector and segmental anatomy: overview

Use of standardized, segmental anatomy facilitates communication of observation location and treatment planning.

Historically, the convention for liver anatomy has been controversial and there are several systems that propose slightly different terminology to identify liver anatomy:

- Couinaud's system: Divided anatomic units into segments 1-8, based on portal scissura
- Bismuth, Healey & Schroy, and Goldsmith & Woodburne: Further revised Couinaud's system with 1) division of liver in two lobes and further into left lateral and medial sectors and right anterior and posterior sectors, and the caudate lobe, and 2) division of segments using hepatic veins and fissures
- Federative committee on anatomical terminology (FCAT): Combines the concepts of both above systems and proposed international standard
- International Hepatopancreaticobiliary Association (IHPBA): Proposed terminology for surgical resection based on anatomical/functional sections: left hemiliver-lateral and medial section, right hemiliver-anterior and posterior section

Both FCAT and IHPBA systems are used commonly in America, recognize the smallest functional units of liver as segments (named according to Couinaud system), and use the nearly interchangeable terms sector or section.

Sector and segmental anatomy: overview

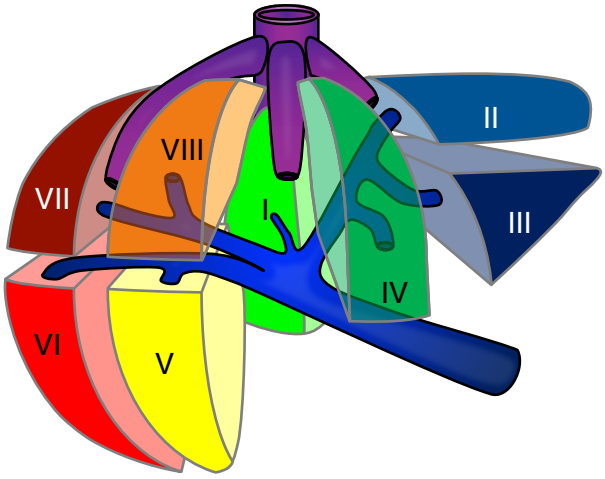
The liver is divided into right and left lobes or hemilivers by the plane of middle hepatic vein. This plane runs from the left of the IVC to the left of the gallbladder fossa (Cantlie's line).

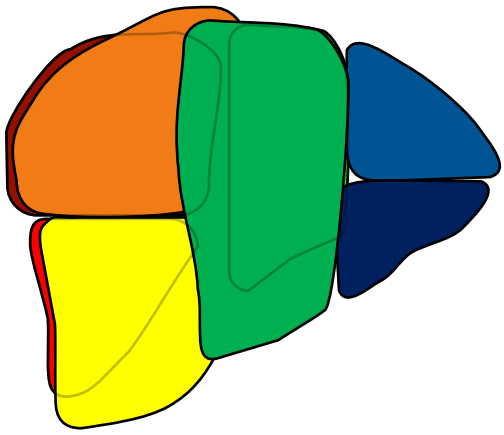
The right lobe is divided into anterior and posterior sectors or sections by the plane of the right hepatic vein.

The left lobe is divided into a medial and lateral sectors or sections by an oblique plane connecting the left hepatic vein and the falciform ligament.

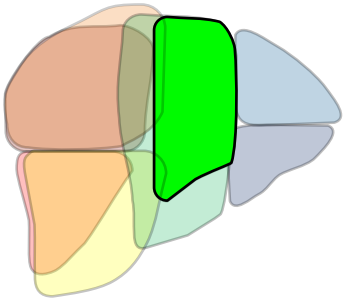
The liver is divided into upper and lower segments at the level of main portal vein (MPV) bifurcation.

Segment I:	Caudate
Segment II:	Superior left lateral sector/section
Segment III:	Inferior left lateral sector/section
Segment IVa:	Superior left medial sector/section
Segment IVb:	Inferior left medial sector/section
Segment V:	Inferior right anterior sector/section
Segment VI:	Inferior right posterior sector/section
Segment VII:	Superior right posterior sector/section
Segment VIII:	Superior right anterior sector/section



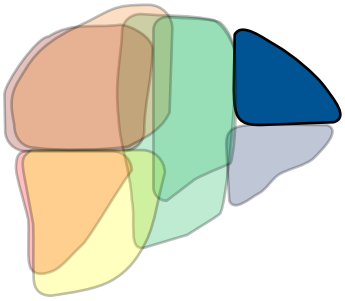


Sector and Segmental Anatomy



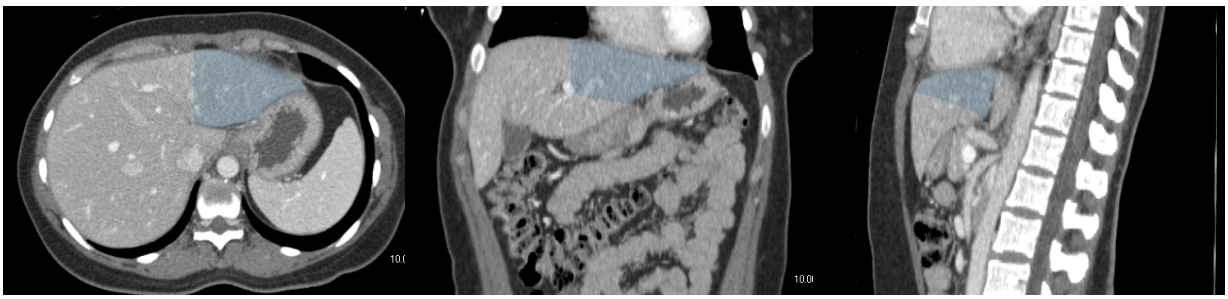
Segment I: Caudate lobe

Bounded anteriorly and medially by the fissure for ligamentum venosum

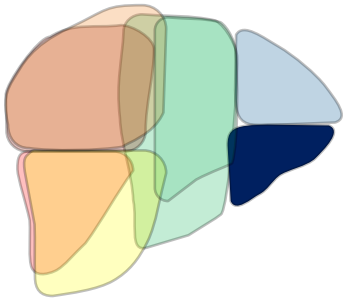


Segment II: Superior segment of the left lateral sector/section

Bounded medially by falciform ligament and inferiorly by plane of MPV, also known as the posterior lateral sector (Bismuth, FCAT)

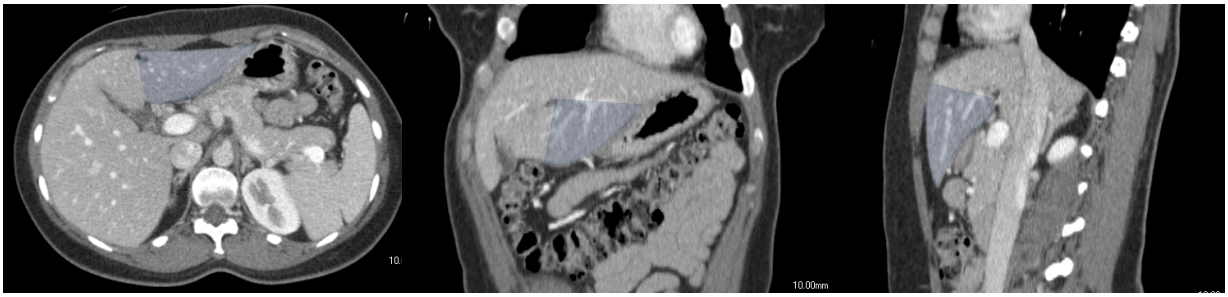


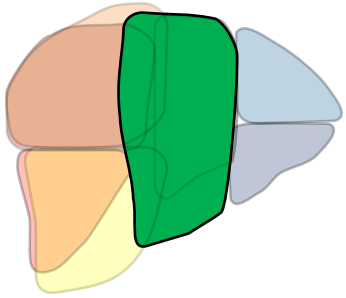
Sector and Segmental Anatomy



Segment III: Inferior segment of left lateral sector/section

Bounded medially by the falciform ligament and superiorly by the plane of the MPV bifurcation, also referred to as lateral anterior sector (Bismuth, FCAT)



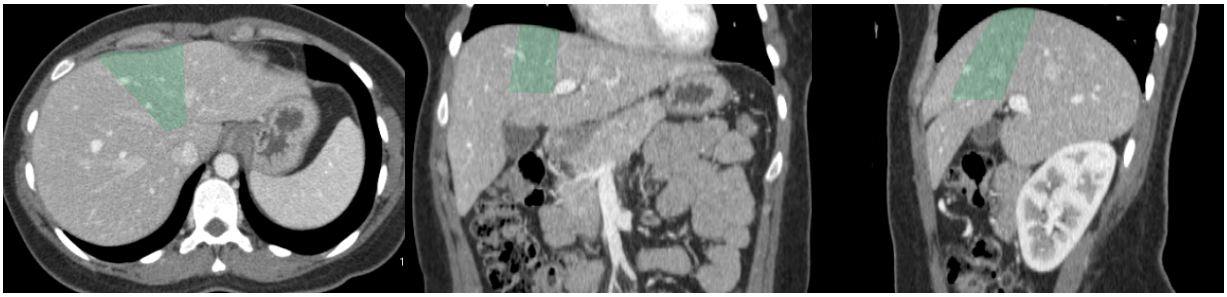


Segment IV: Left medial sector/section

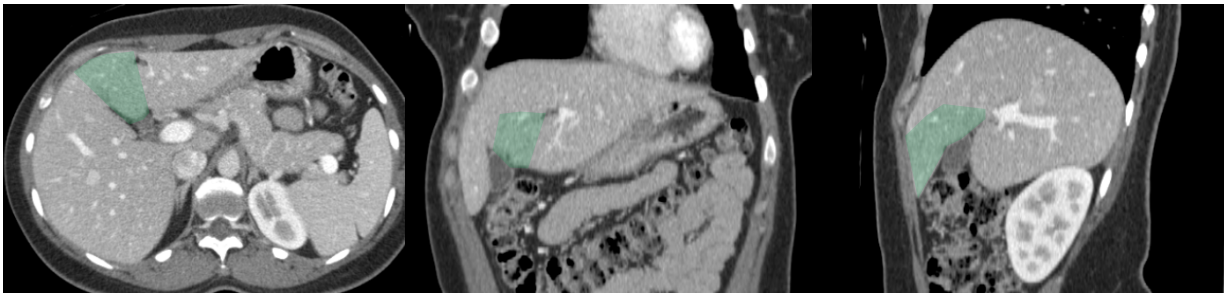
Bounded laterally by falciform ligament and medially by Cantlie's line

- IVa: Superior to the MPV bifurcation
- IVb: Inferior to the MPV bifurcation

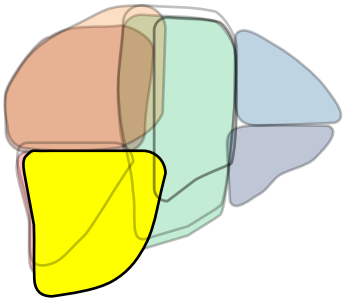
IVa



IVb



Sector and Segmental Anatomy



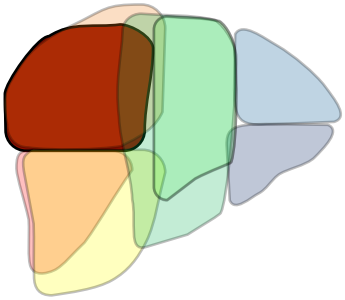
Segment V: Inferior segment of the right anterior sector/section

Bounded anteriorly by the gallbladder fossa and posteriorly by the plane of the right hepatic vein, superiorly bounded by the plane of MPV bifurcation

Segment VI: Inferior segment of the right posterior sector/section

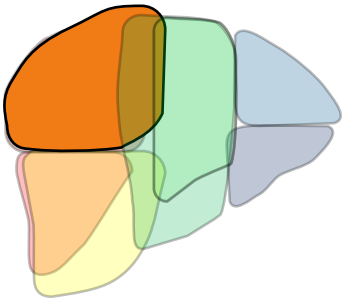
Bounded anteriorly by plane of the right hepatic vein and superiorly by the plane of the MPV bifurcation

Sector and Segmental Anatomy



Segment VII: Superior segment of the right posterior sector/section

Bounded anteriorly by the plane of the right hepatic vein and inferiorly by the plane of the MPV bifurcation



Segment VIII: Superior segment of the right anterior sector/section

Bounded anteriorly by the plane of the gallbladder fossa and middle hepatic vein, posteriorly bounded by the plane of the right hepatic vein and inferiorly by the plane of the MPV bifurcation

Arterial, Portal, and Biliary Anatomy

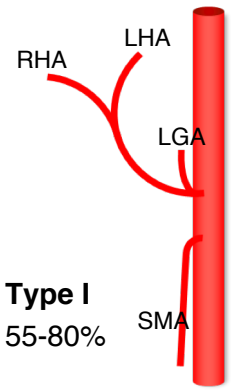
Radiologists should be aware of anatomic variants in arterial supply, portal venous supply, and biliary drainage as these may affect treatment planning.

The next few pages illustrate the most common variants.

It is not necessary for radiologists to memorize the names of the variants, as they can be reported descriptively.

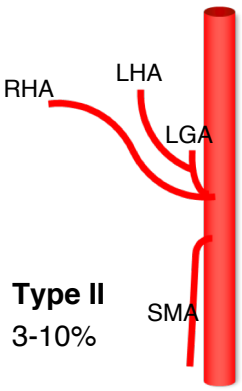
Arterial Anatomy

Michel Classification



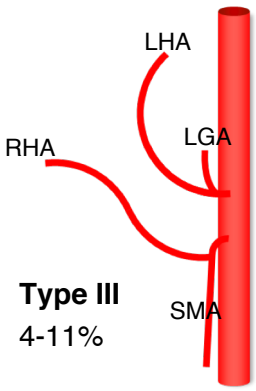
Type I
55-80%

RHA and LHA arise from CHA



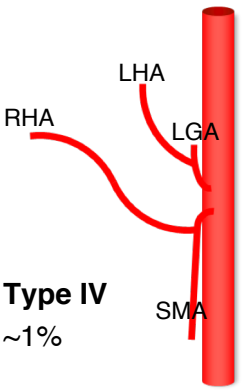
Type II
3-10%

RHA arises from CHA; replaced LHA from LGA



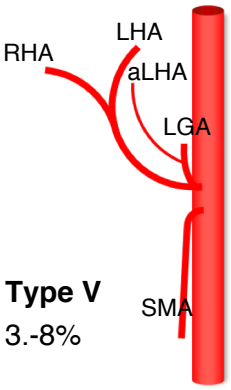
Type III
4-11%

LHA arises from CHA; replaced RHA from SMA



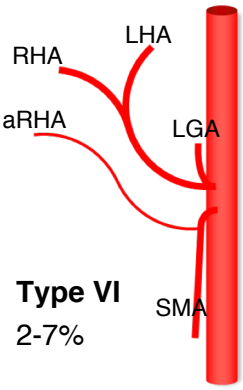
Type IV
~1%

Replaced RHA and LHA



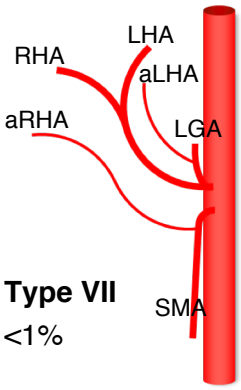
Type V
3.-8%

RHA and LHA arise from CHA; accessory LHA from LGA



Type VI
2-7%

RHA and LHA arise from CHA; accessory RHA from SMA



Type VII
<1%

RHA and LHA arise from CHA; accessory RHA and LHA

RHA: right hepatic artery

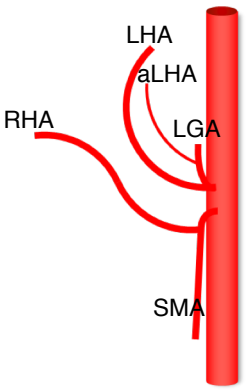
LHA: left hepatic artery

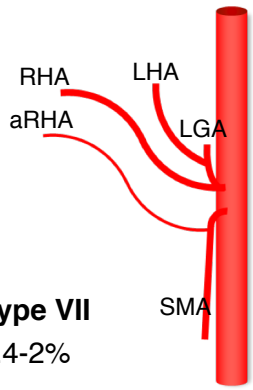
LGA: left gastric artery

SMA: superior mesenteric artery

aRHA: accessory RHA

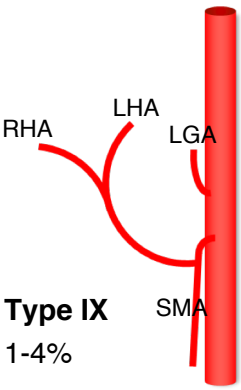
aLHA: accessory LHA





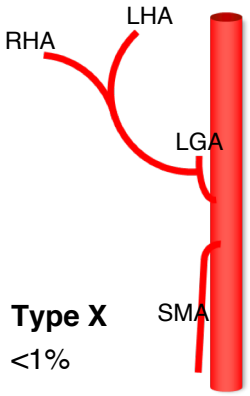
Type VII
0.4-2%

Replaced RHA or LHA with other hepatic artery being an accessory one



Type IX
1-4%

The hepatic trunk arises as a branch of the SMA

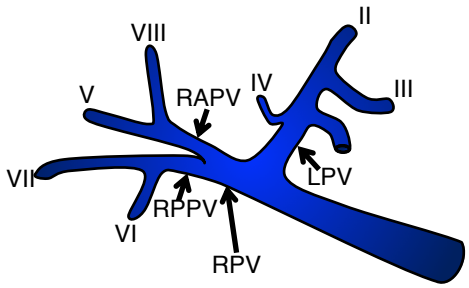


Type X
<1%

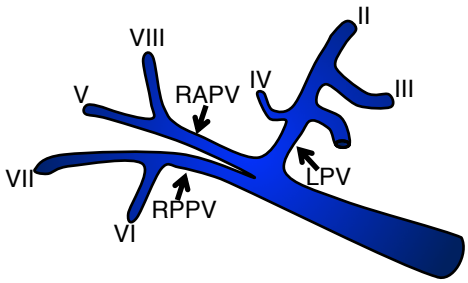
The hepatic trunk arises from the left gastric artery

Portal Venous Anatomy

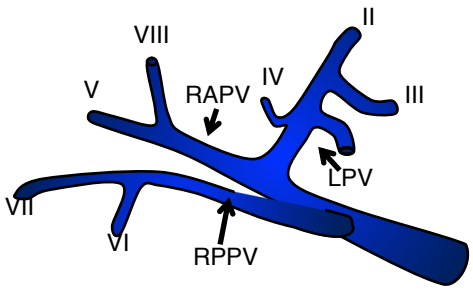
The standard portal venous anatomy consists of the main portal trunk branching into the right and left portal veins, with the right portal vein subsequently dividing into anterior and posterior branches.



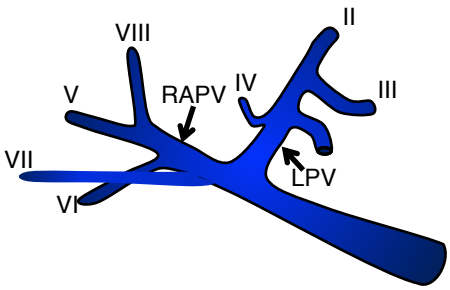
Standard anatomy
(65-80%)



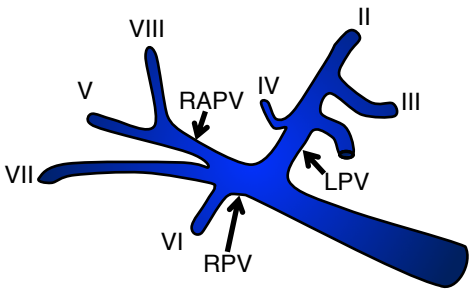
Main portal vein trifurcation into right anterior, right posterior and left portal vein (7-9%)



Right posterior portal vein as first branch of main portal vein
(5-13%)



Segment VII branch as separate branch of right portal vein
(1-3%)

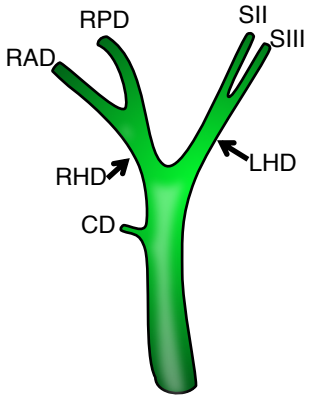


Segment VI branch as separate branch of right portal vein(1-6%)

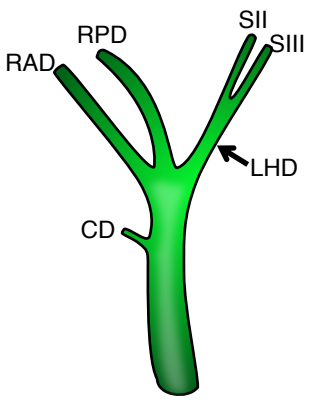
RAPV: right anterior portal vein
RPPV: right posterior portal vein
RPV: right portal vein
LPV: left portal vein

Biliary Anatomy

The standard biliary anatomy consists of the right hepatic duct and left hepatic duct joining together to form common hepatic duct.

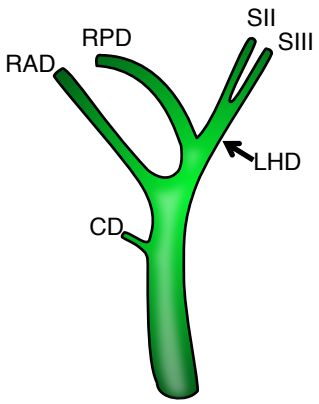


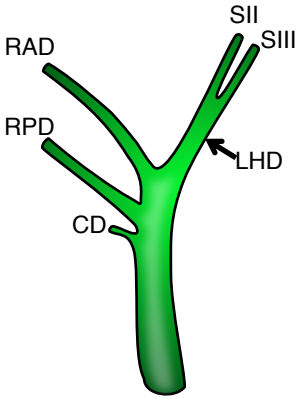
Standard anatomy (63%)

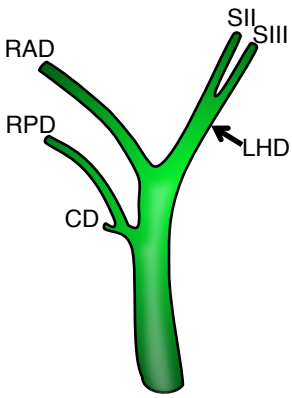


Triple confluence (10%)

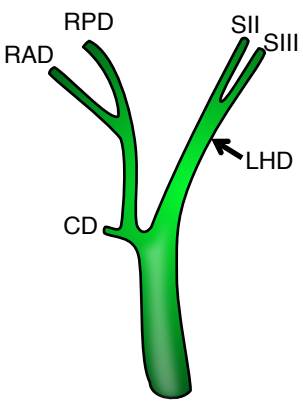
CHD: Common hepatic duct
RHD: Right hepatic duct
LHD: Left hepatic duct
RAD: Right anterior duct
RPD: Right posterior duct
SII: Duct to segment II
SIII: Duct to segment III
CD: Cystic duct
Acc: Accessory duct



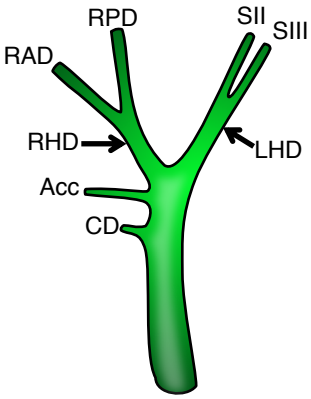




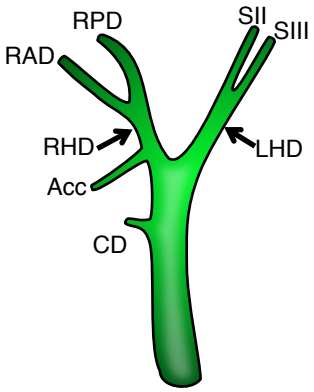
Right posterior segmental duct drains anomalously into LHD (11%), CHD (6%) or cystic duct (2%)

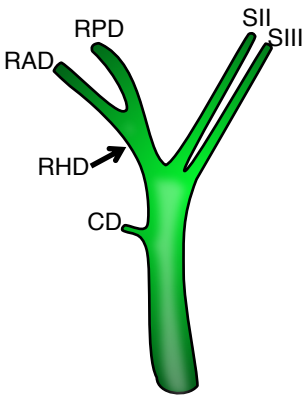


RHD drains into cystic duct (<1%)



Accessory duct arises either from CHD (3%) or RHD (3%)





Ducts of segments II and III drain individually into CHD (1%)

References

Botero AC, Strasberg SM. Division of the left hemiliver in man--segments, sectors, or sections. Liver Transpl Surg. 1998 May;4(3):226-31

Catalano OA, Singh AH, Uppot RN, Hahn PF, Ferrone CR, Sahani DV. Vascular and biliary variants in the liver: implications for liver surgery. Radiographics. 2008 Mar-Apr;28(2):359-78

Choi JW, Kim TK, Kim KW, Kim AY, Kim PN, Ha HK, Lee MG. Anatomic variation in intrahepatic bile ducts: an analysis of intraoperative cholangiograms in 300 consecutive donors for living donor liver transplantation. Korean J Radiol. 2003 Apr-Jun;4(2):85-90.

Covey AM, Brody LA, Getrajdman GI, Sofocleous CT, Brown KT. Incidence, patterns, and clinical relevance of variant portal vein anatomy. AJR 2004 Oct;183(4):1055-64.

Covey AM, Brody LA, Maluccio MA, Getrajdman GI, Brown KT. Variant hepatic arterial anatomy revisited: digital subtraction angiography performed in 600 patients. Radiology. 2002 Aug;224(2):542-7.

Furuta T, Maeda E, Akai H, Hanaoka S, Yoshioka N, Akahane M, Watadani T, Ohtomo K. Hepatic segments and vasculature: projecting CT anatomy onto angiograms. Radiographics. 2009 Nov;29(7):1-22. doi: 10.1148/rg.e37.

Michels NA. Newer anatomy of the liver and its variant blood supply and collateral circulation. Am J Surg. 1966 Sep;112(3):337-47.

Mortelé KJ, Ros PR. Anatomic variants of the biliary tree: MR cholangiographic findings and clinical applications. AJR 2001 Aug;177(2):389-94.

Murakami G, Hata F. Human liver caudate lobe and liver segment. Anat Sci Int. 2002 Dec;77(4):211-24.

Noussios G, Dimitriou I, Chatzis I, Katsourakis A. The Main Anatomic Variations of the Hepatic Artery and Their Importance in Surgical Practice: Review of the Literature. J Clin Med Res. 2017 Apr;9(4):248-252.

Sureka B, Patidar Y, Bansal K, Rajesh S, Agrawal N, Arora A. Portal vein variations in 1000 patients: surgical and radiological importance. Br J Radiol.2015;88(1055):20150326.

Winter TC 3rd, Nghiem HV, Freeny PC, Hommeyer SC, Mack LA. Hepatic arterial anatomy: demonstration of normal supply and vascular variants with three-dimensional CT angiography. Radiographics. 1995 Jul;15(4):771-80.

Zhou XP, Lu T, Wei YG, Chen XZ. Liver volume variation in patients with virus-induced cirrhosis: findings on MDCT. AJR 2007 Sep;189(3):W153-9.