Surgical Anatomy of the Bile ductal System

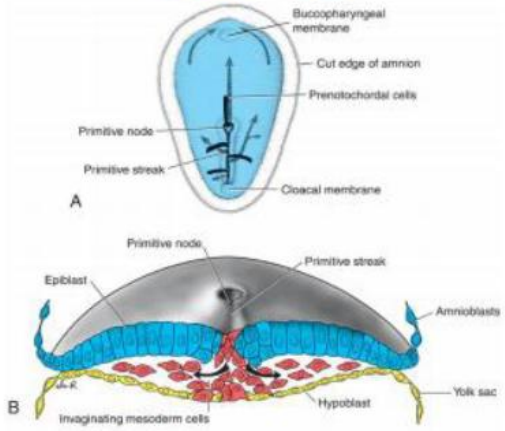
Dimosthenis Chrysikos MD,PhD
General Surgeon
Assistant Professor NKUA

"Surgeons are not just technicians!"

John E Scandalakis
(personal communication)

Origin of The Gut Tissues

WEEK 3

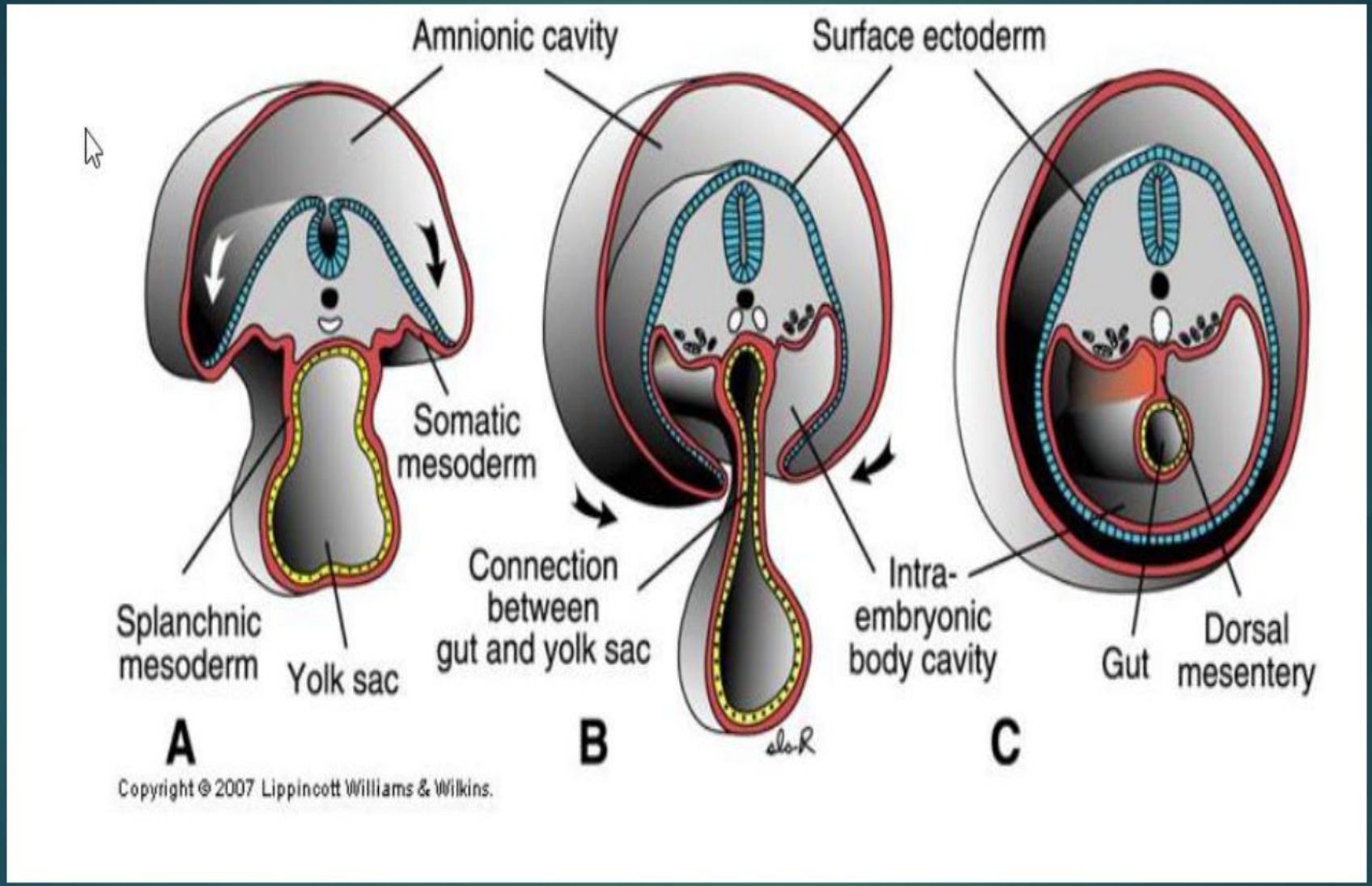


ECTODERM

MESODERM

ENDODERM

- Lining
- Muscle, vessels, immune component connective tissue
- Enteric Nerves


Amnionic cavity
Surface ectoderm
Somatic mesoderm
Splanchnic mesoderm
Yolk sac
Connection between gut and yolk sac
Intra-embryonic body cavity
Gut
Dorsal mesentery
A
B
C
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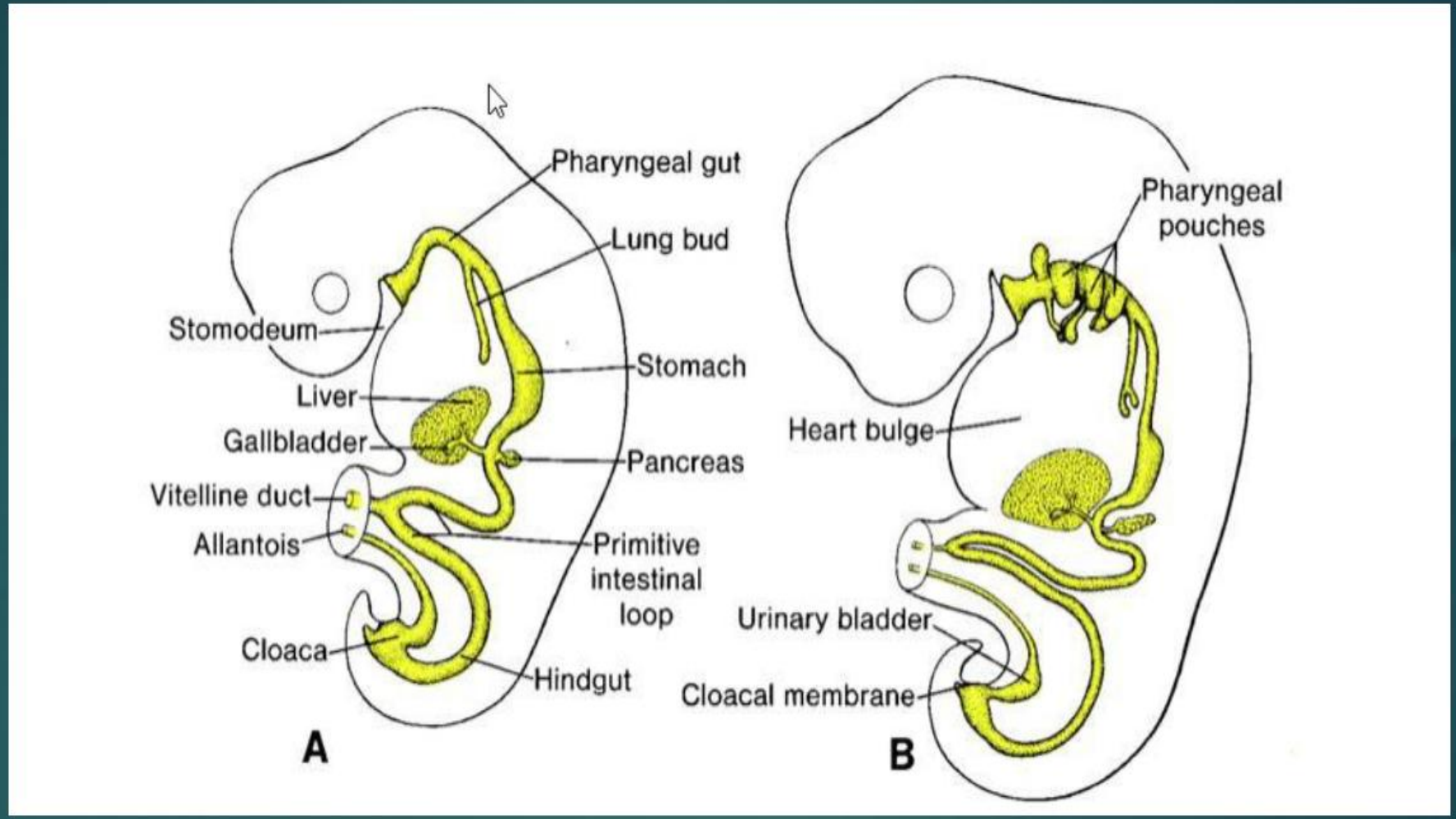
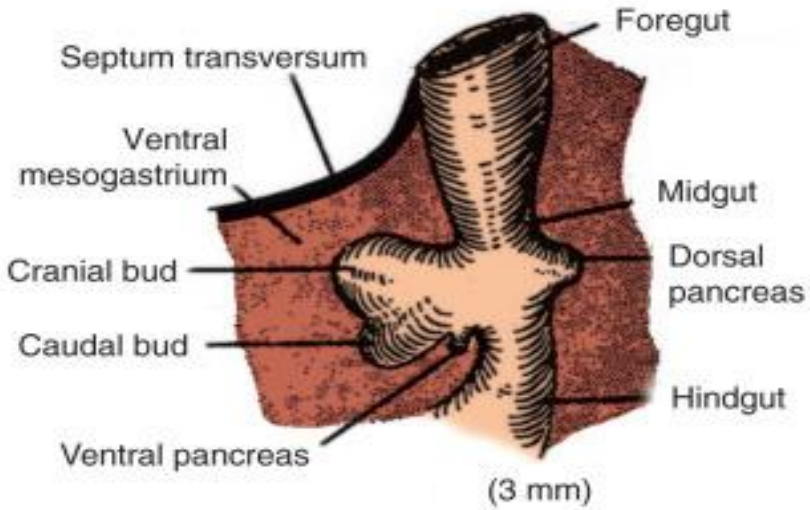

Pharyngeal gut
Lung bud
Stomodeum
Stomach
Liver
Gallbladder
Pancreas
Vitelline duct
Allantois
Primitive intestinal loop
Cloaca
Hindgut
A
Pharyngeal pouches
Heart bulge
Urinary bladder
Cloacal membrane
B



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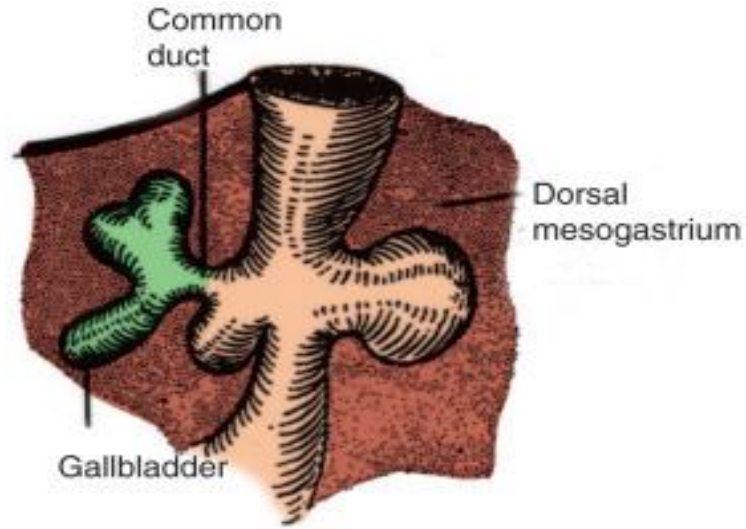

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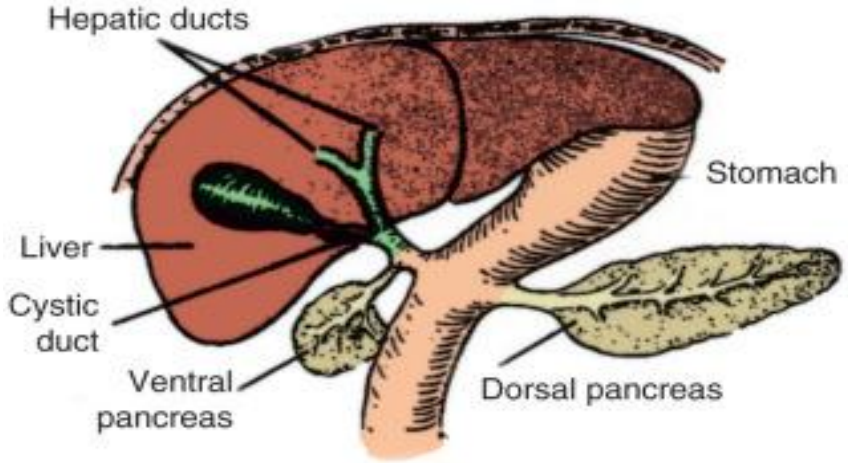

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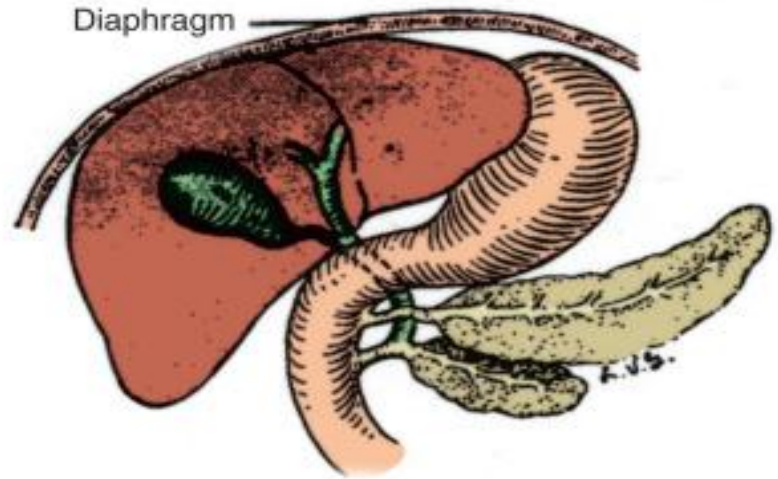


(12 mm)

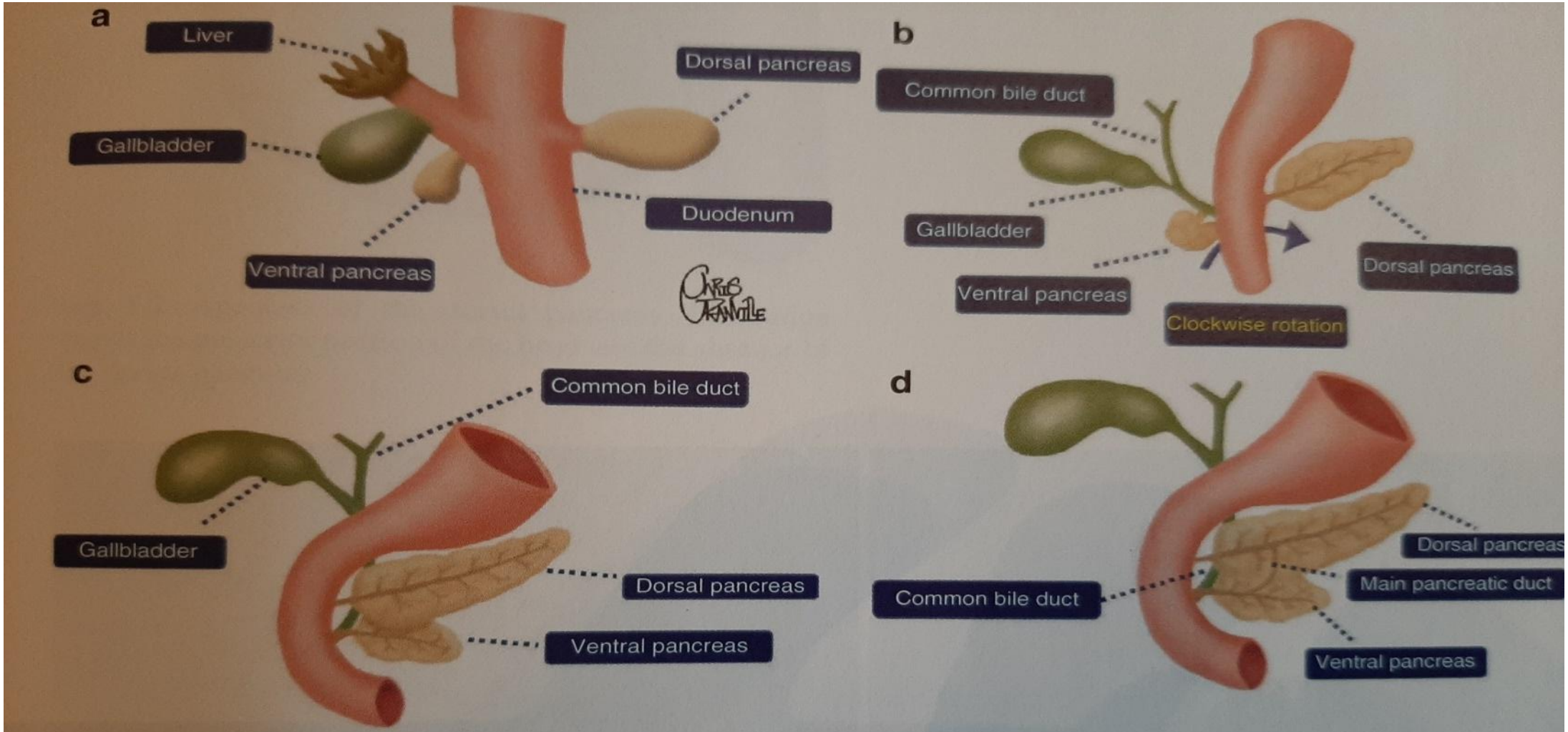
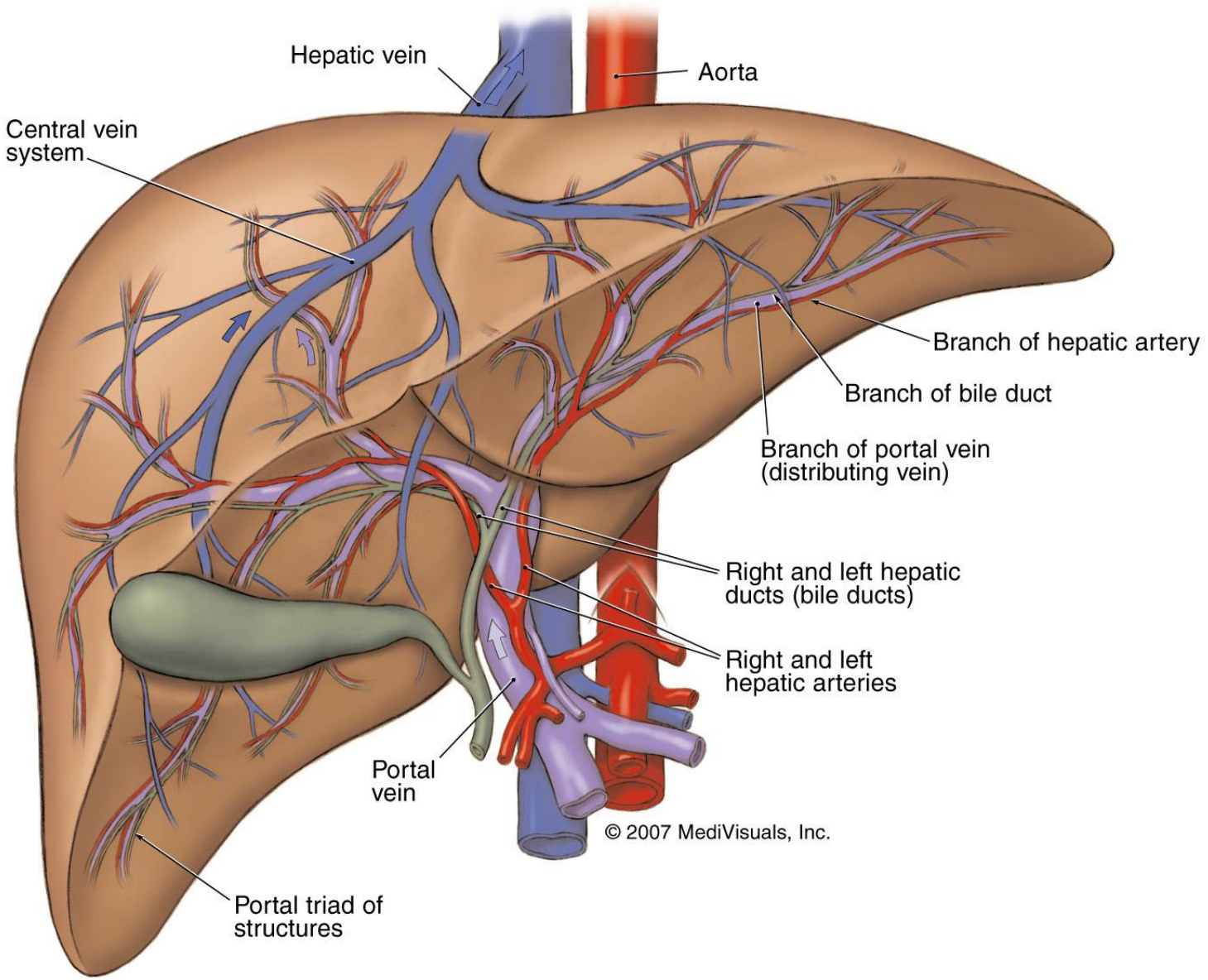
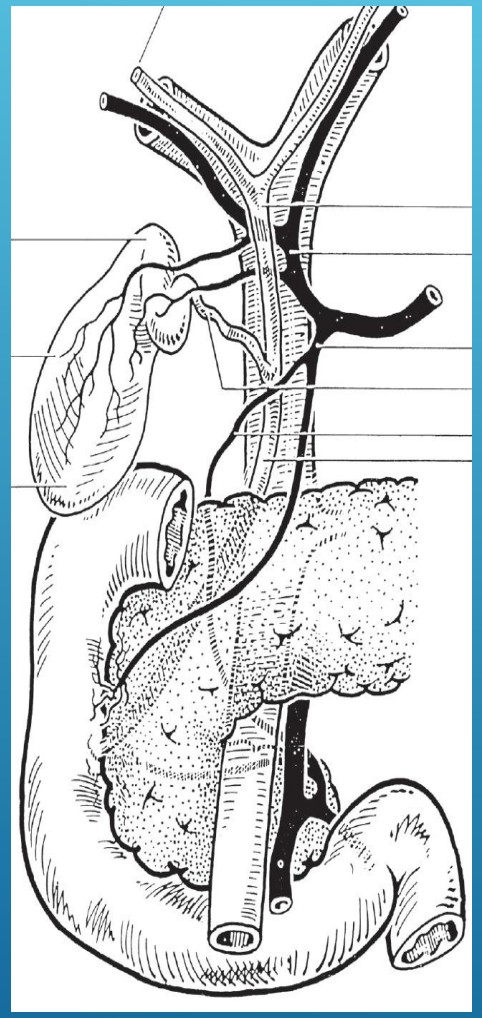


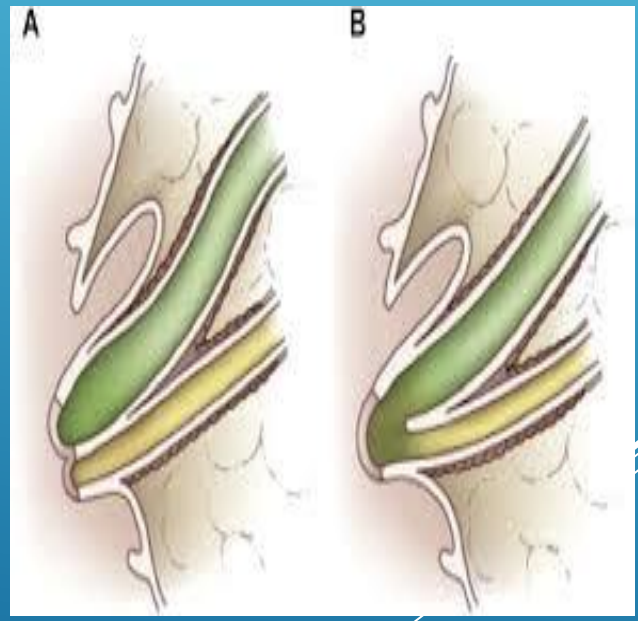
Fig. 1.1 Schematic illustration of the embryologic development of the pancreas. (**a**) At about 4 weeks of gestation, the primitive pancreas is formed by a dorsal pancreatic and ventral pancreatic bud that arises from the endodermal lining of the duodenum. (**b**) At 6 weeks, the ventral bud and the bile duct rotate clockwise behind the duodenum (*curved arrow*). (**c**) The ventral pancreatic bud lay posteroinferior to the dorsal pancreatic bud. (**d**) By abo 7 weeks, upon reaching its final destination, the dors pancreatic bud fuses with the ventral pancreatic bud form the final pancreas

Internal Anatomy of Liver



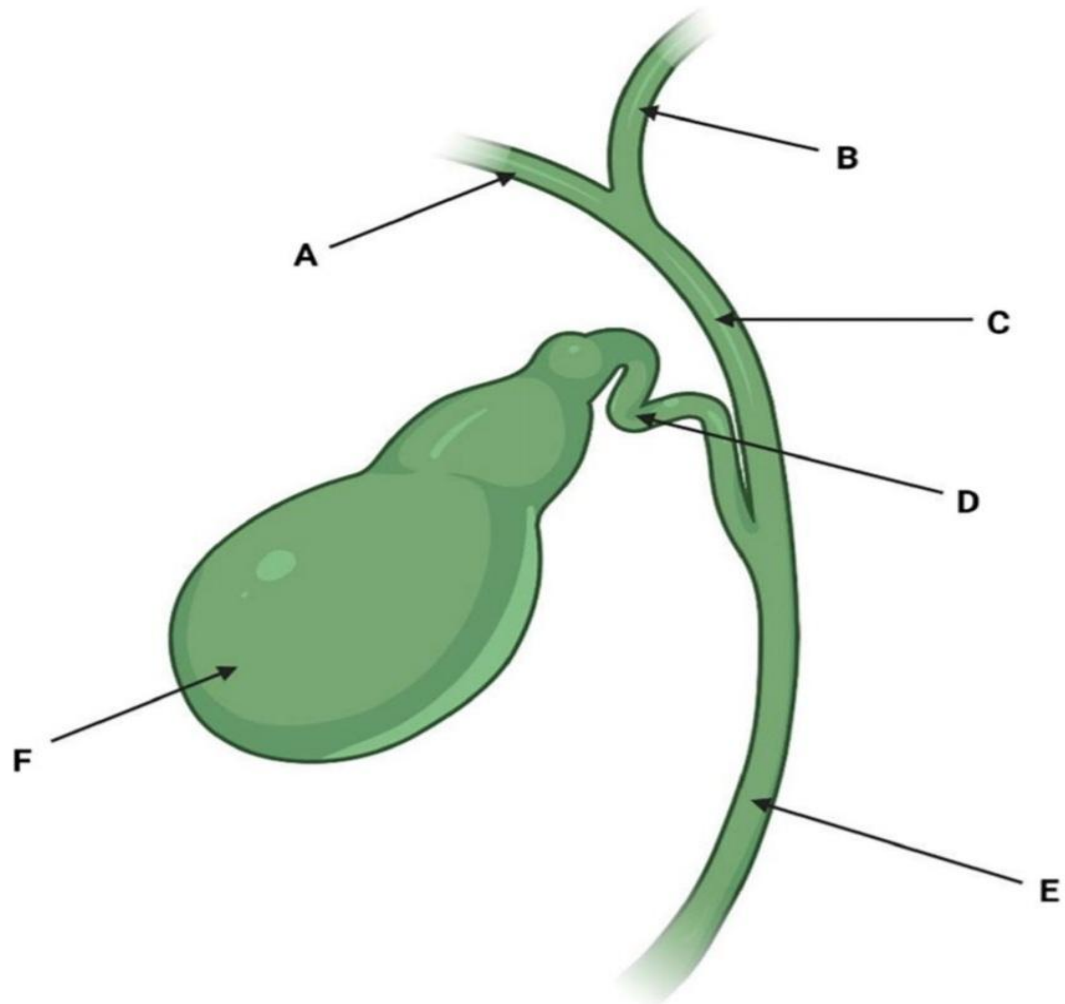
EXTRAHEPATIC BILE DUCTS





Chapter 1: Anatomy and physiology of the biliary tree and gallbladder

James Toouli


A
B
C
D
E
F

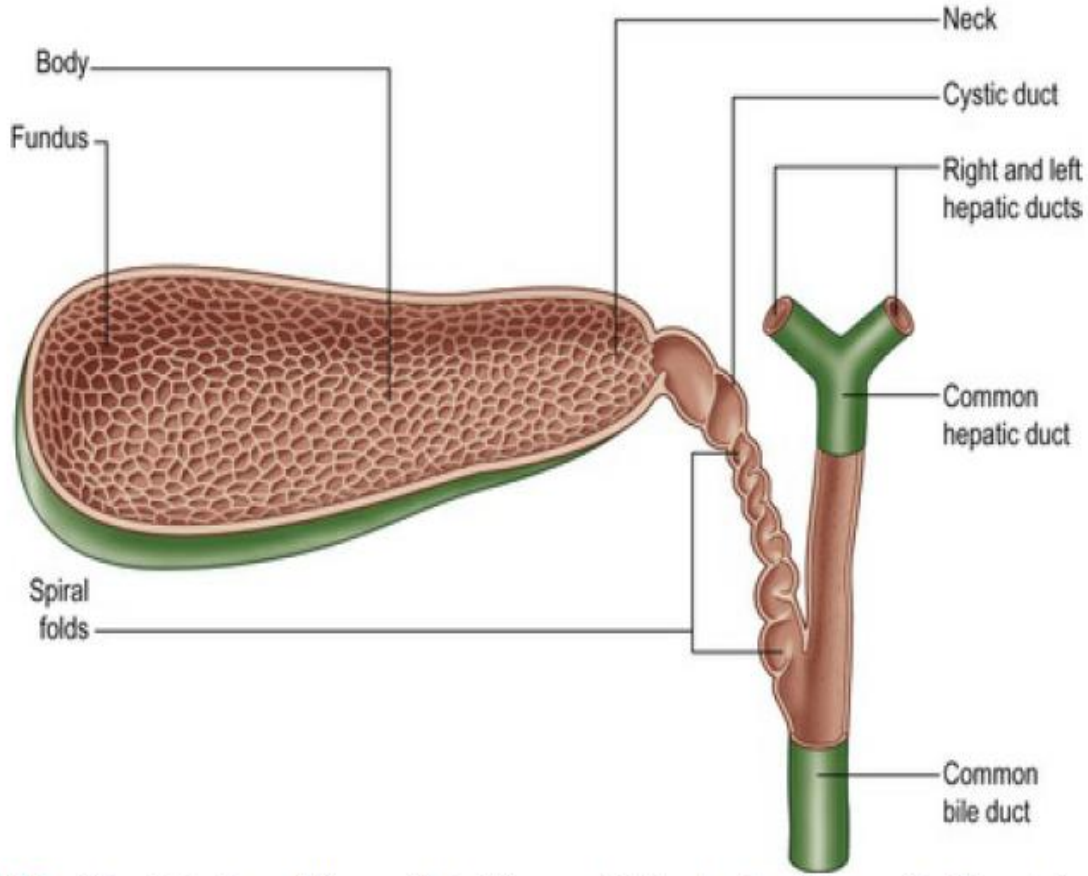
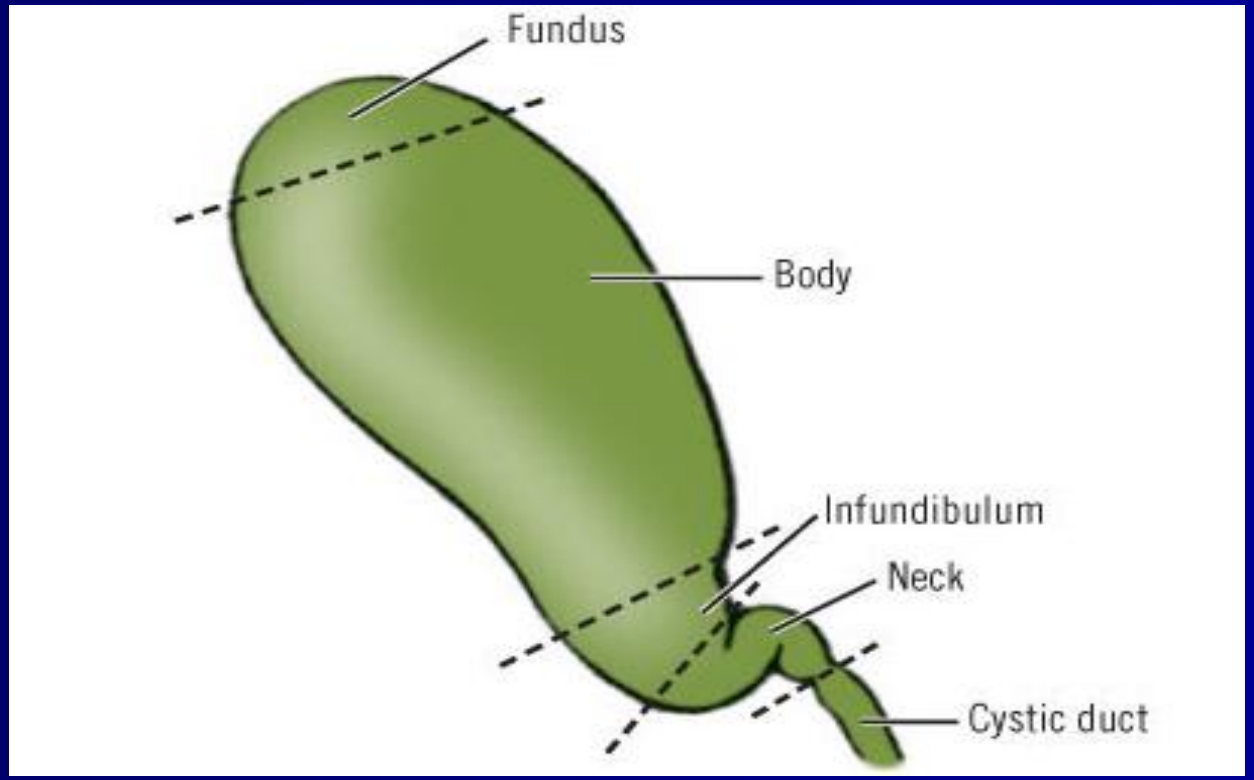
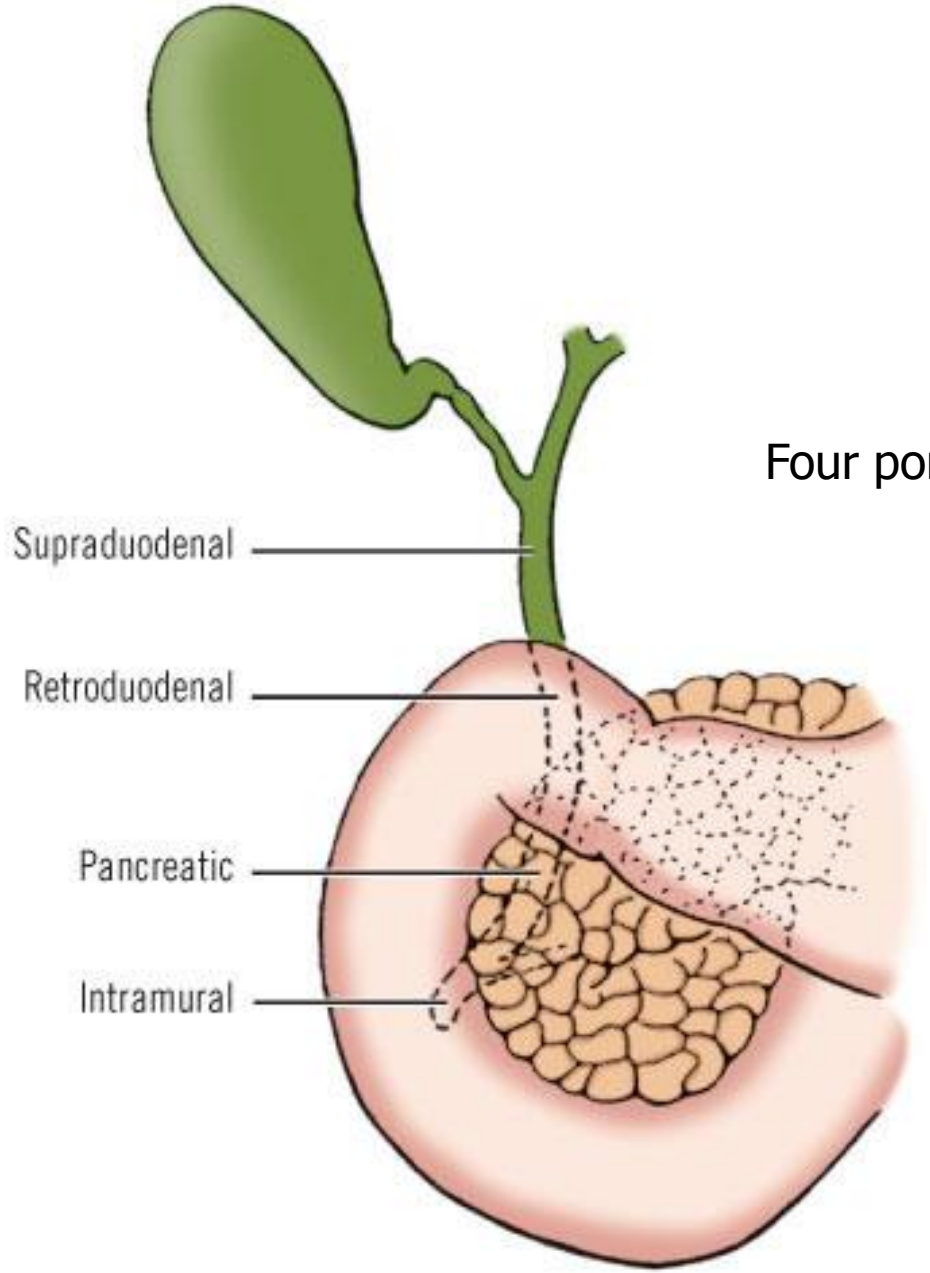
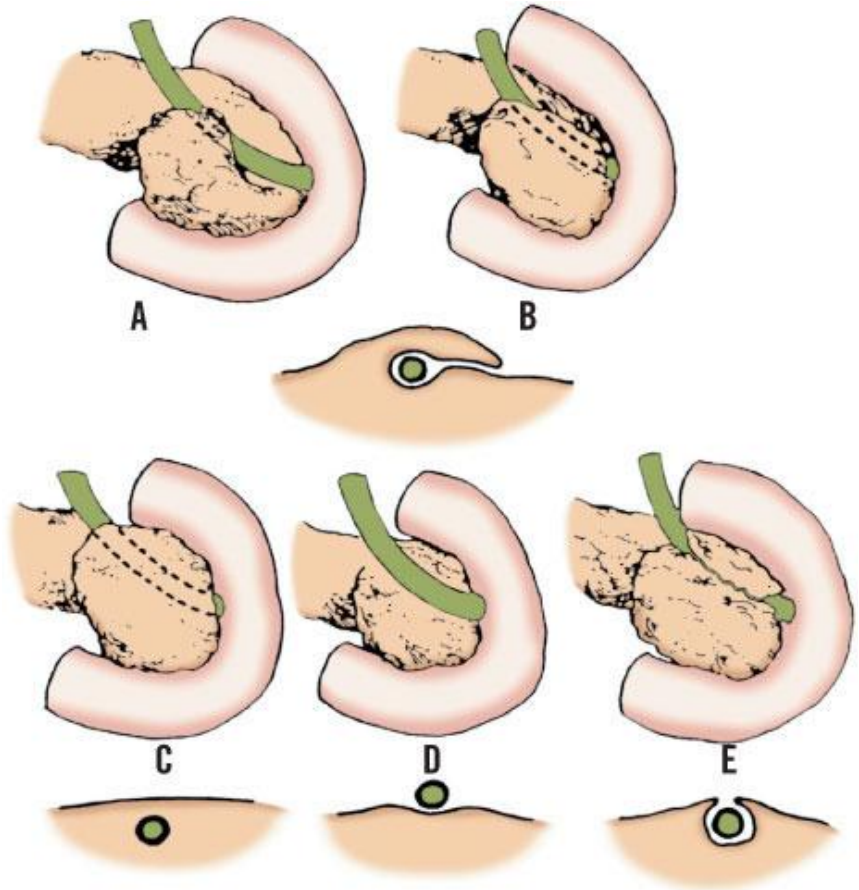


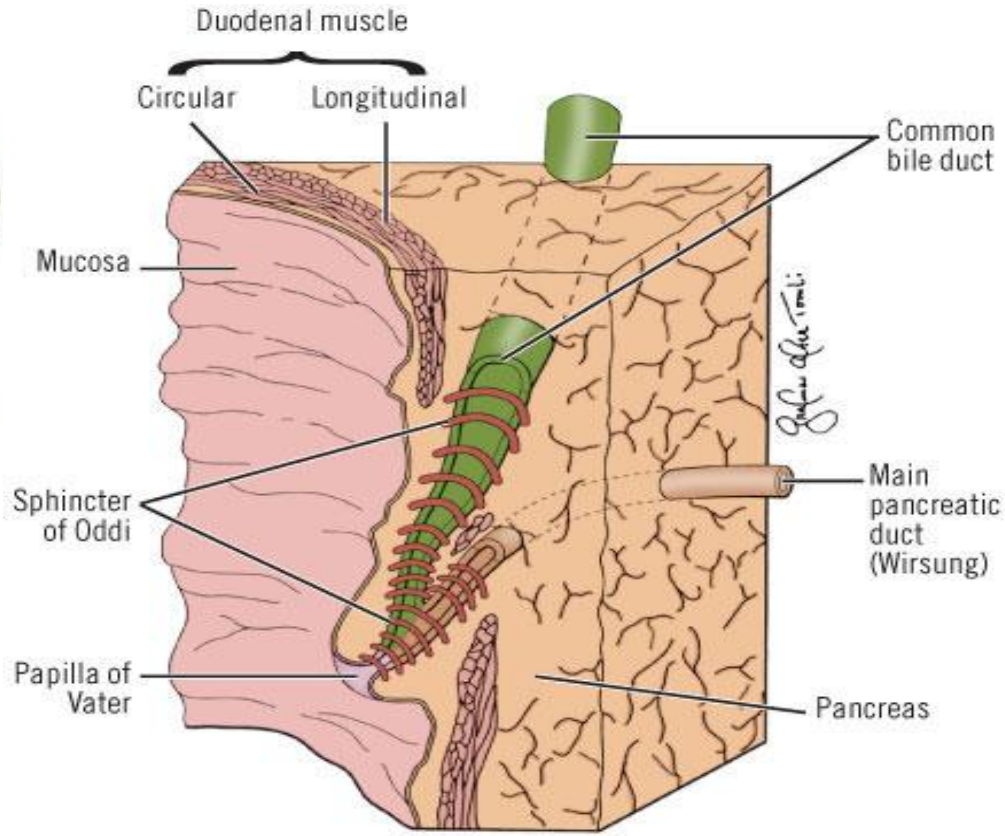
FIG. 54.9 The interior of the gallbladder and bile ducts. (From S. Standring (ed.), Gray's Anatomy, forty-first ed. © Elsevier, 2016, Fig. 68.2.)

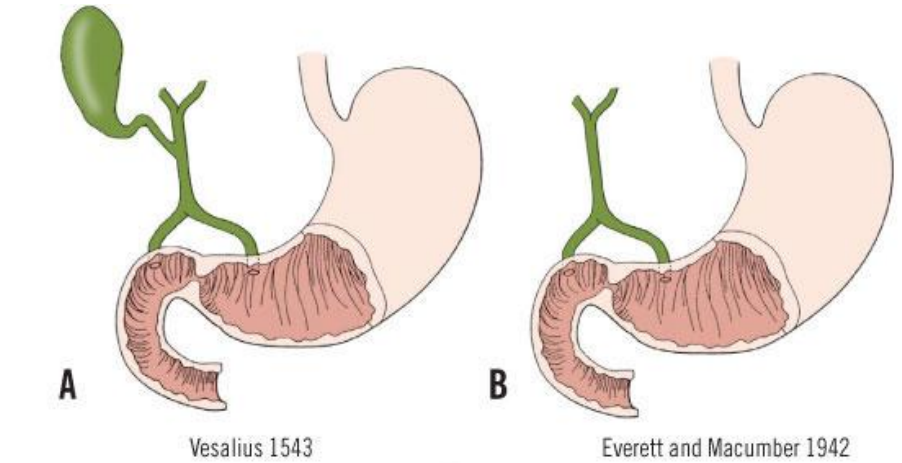

Fundus
Body
Infundibulum
Neck
Cystic duct

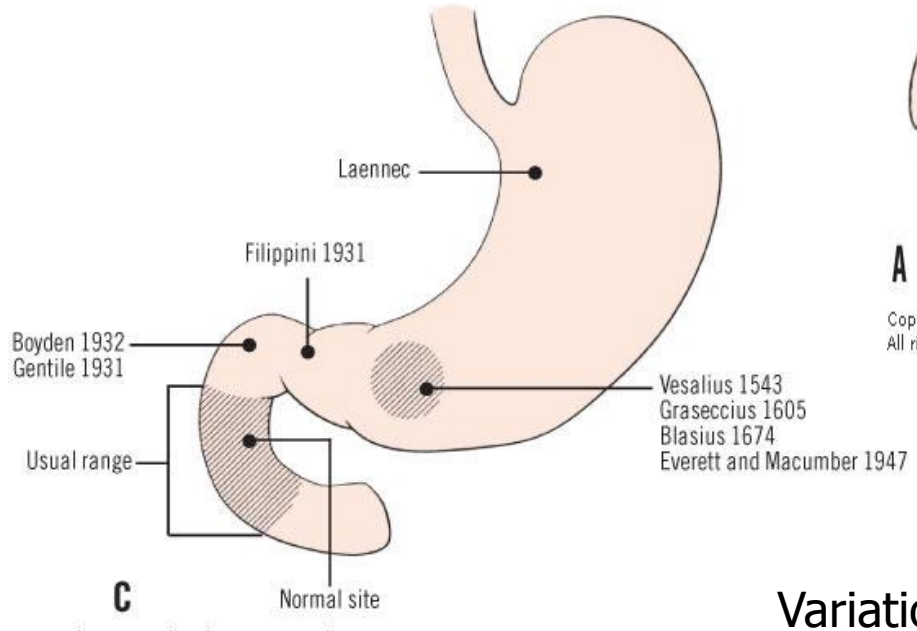


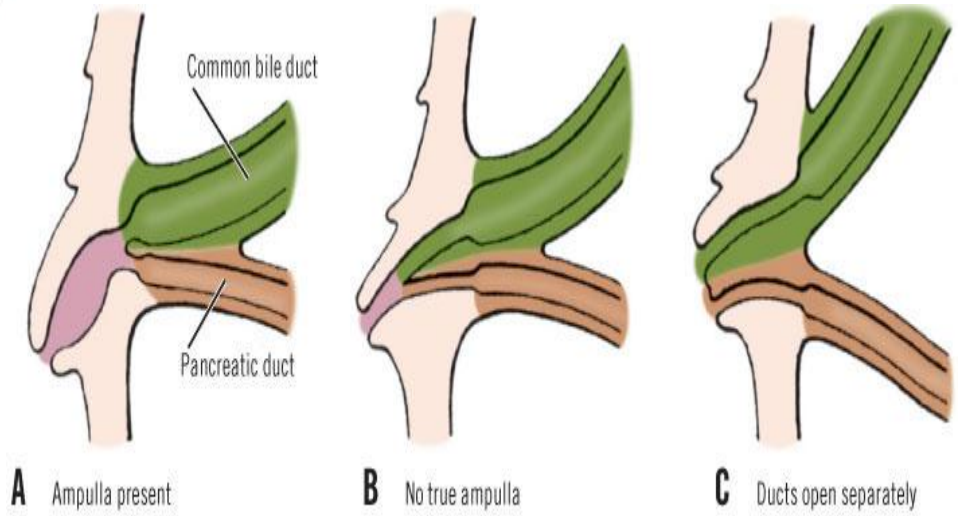
Four portions of common bile duct.





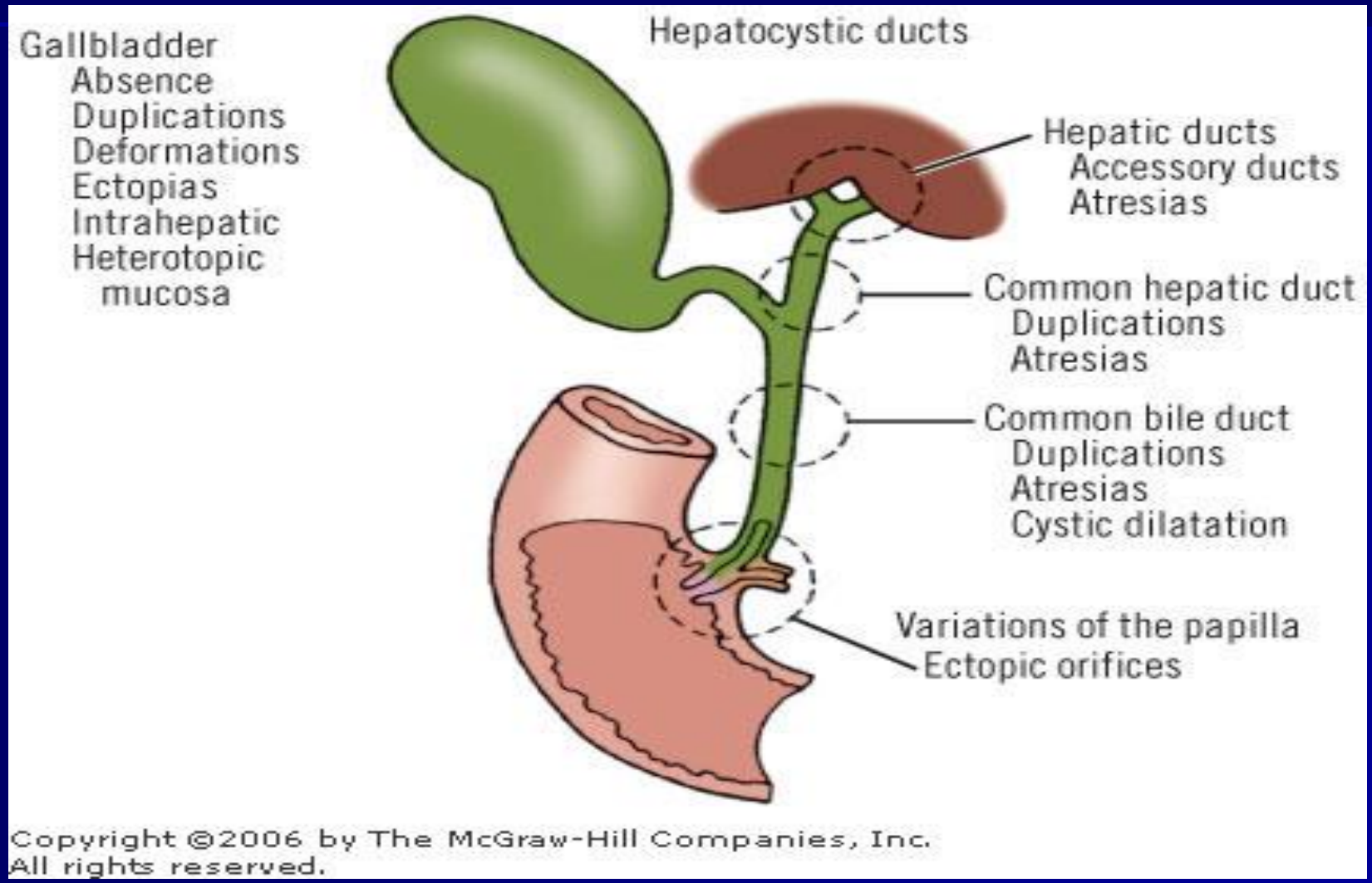




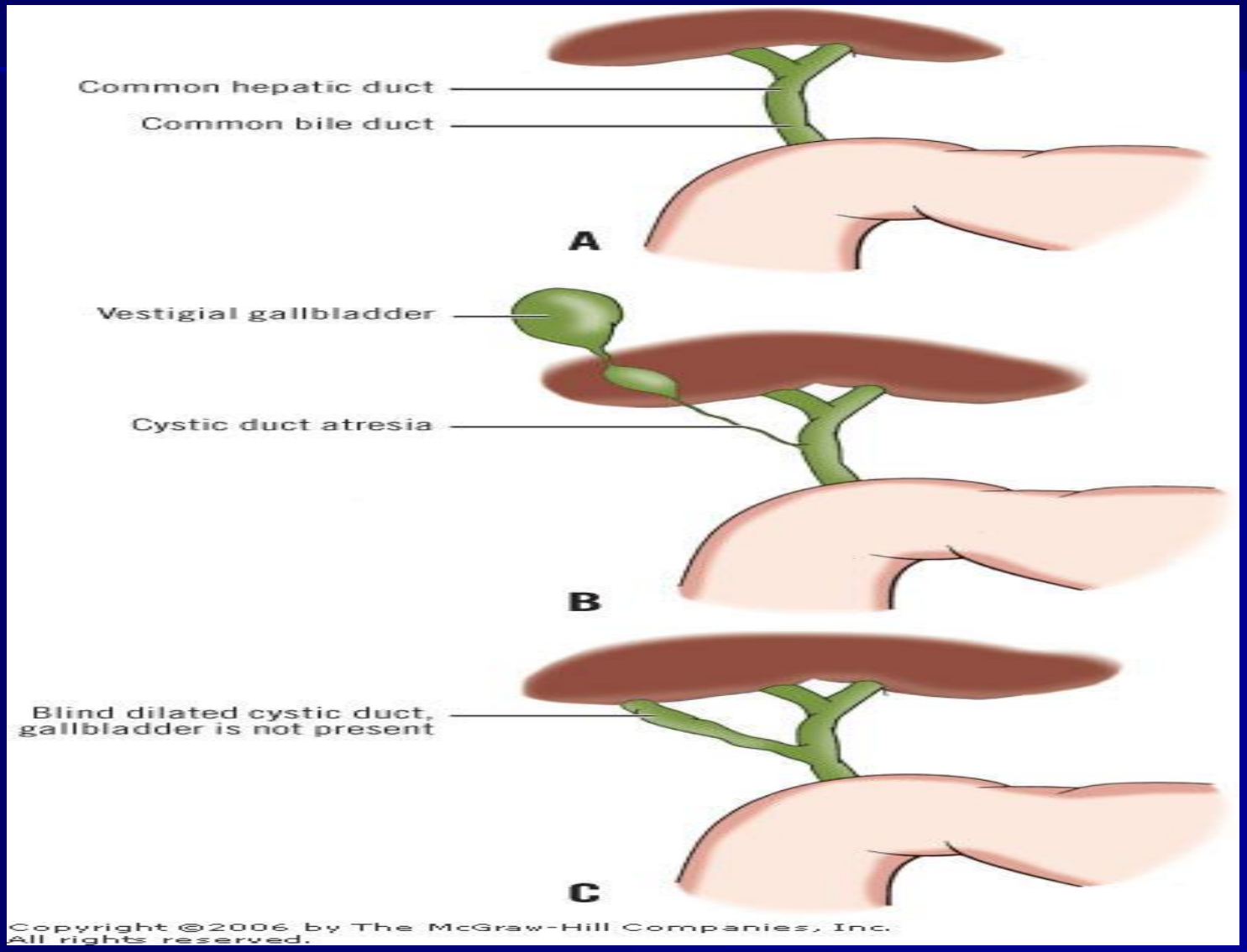


Variations of opening of common bile duct and pancreatic duct into duodenum.

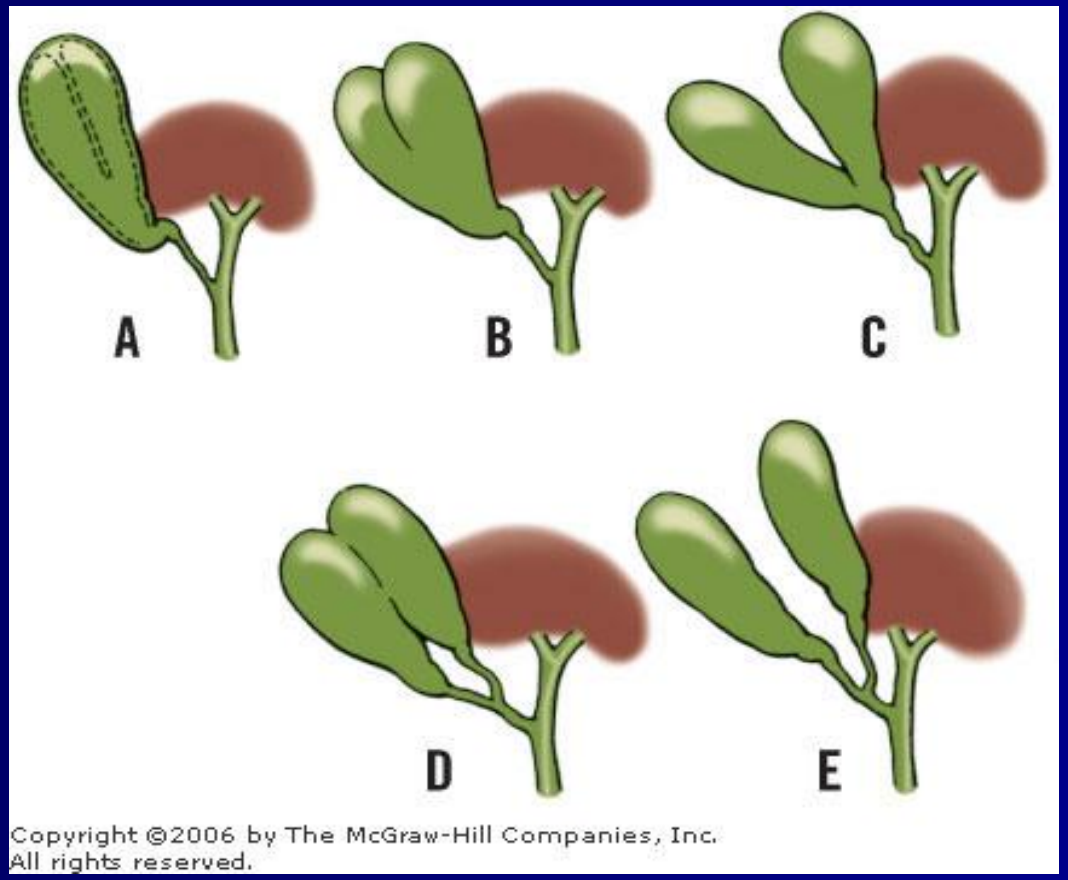
Sites of potential biliary tract malformations



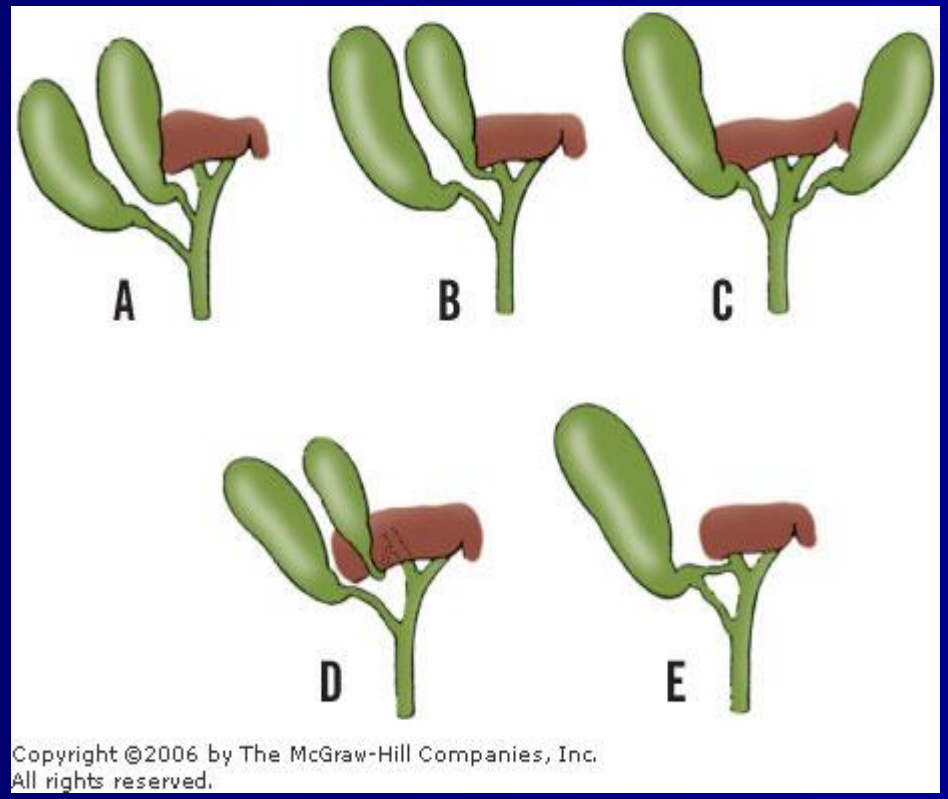
Anomalies GB

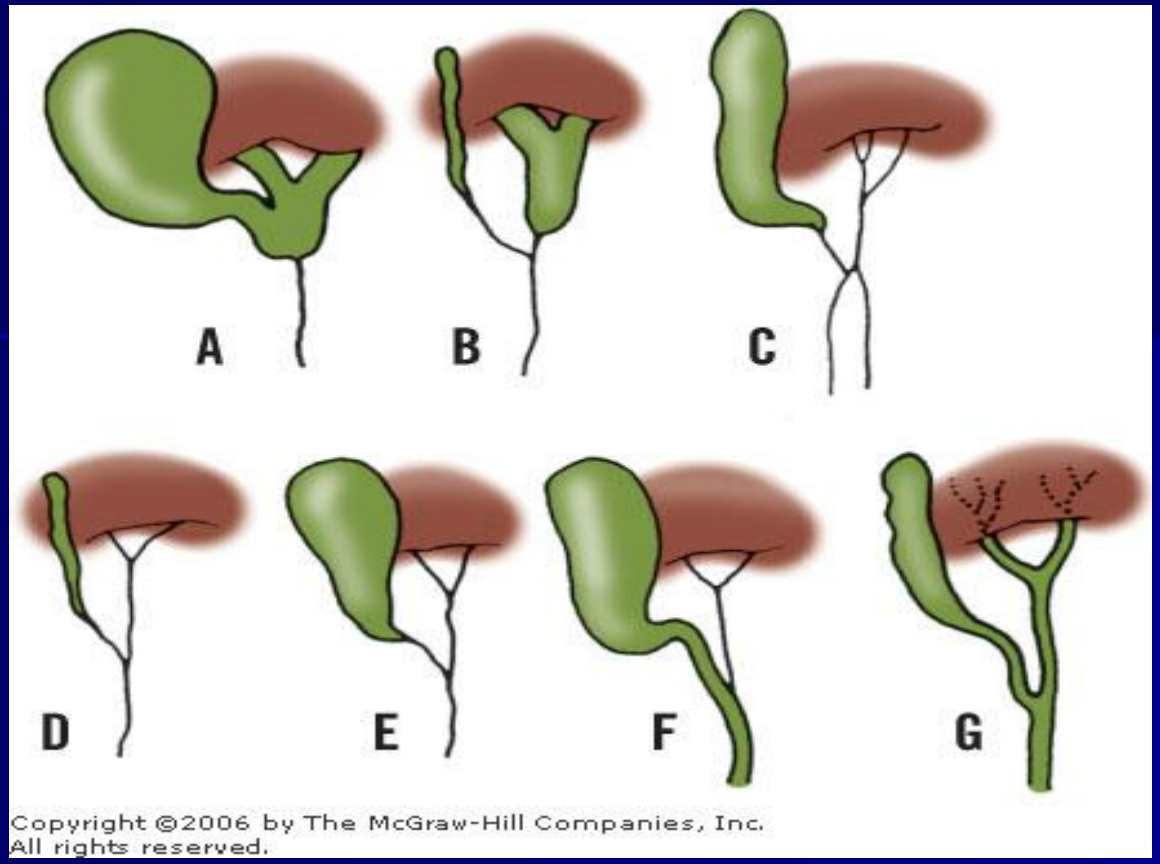


Double GB



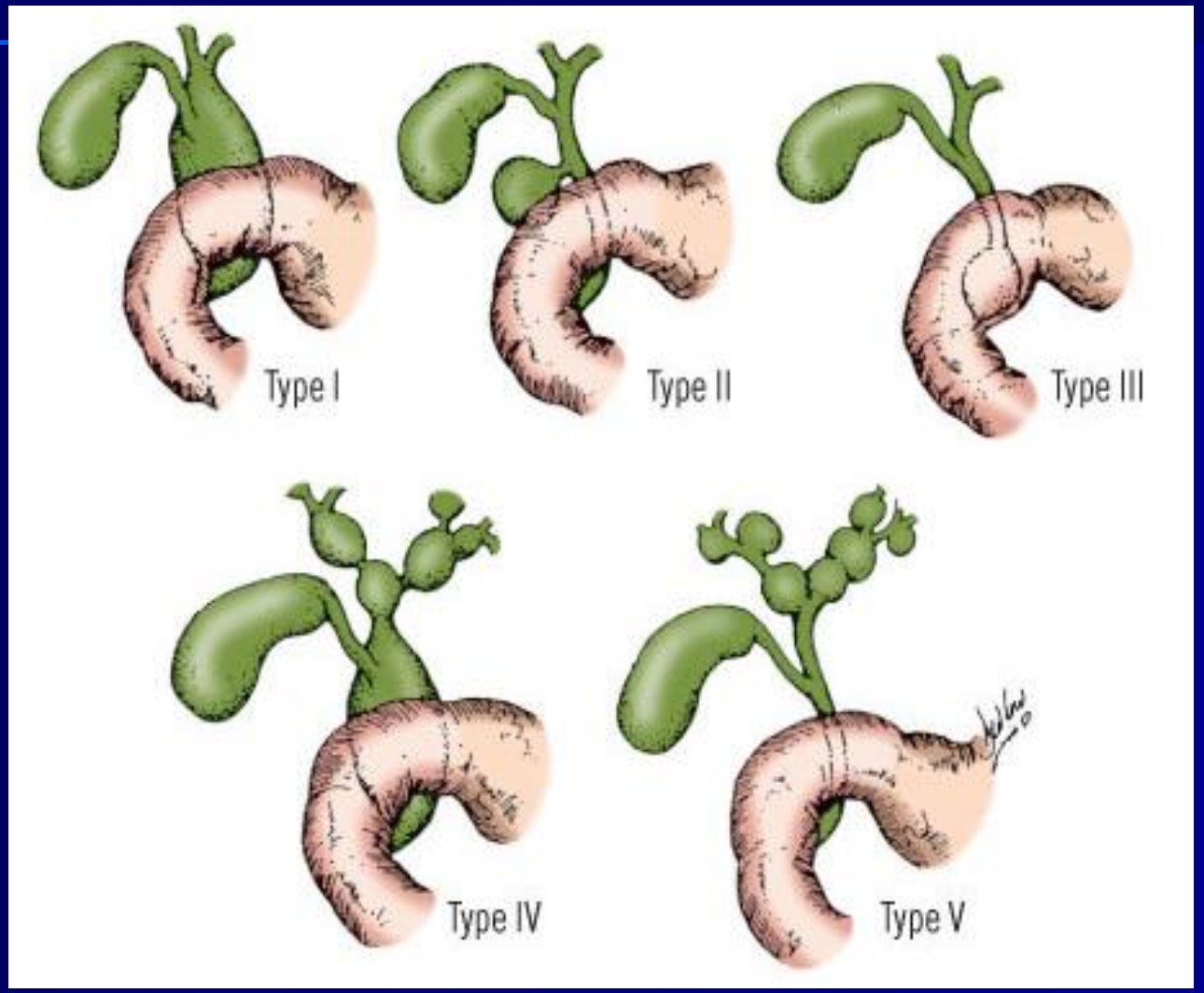
Accesory GB





Atresias of biliary tract. **A-F,** Extrahepatic biliary atresias. **G,** Intrahepatic atresia with normal extrahepatic ducts. Defects **A-C** are "correctable"; at least one patent duct emerges from the liver. **D-G** are termed "noncorrectable." (Modified from Skandalakis JE, Gray SW. Embryology for Surgeons. 2nd ed. Baltimore: Williams & Wilkins, 1994; with permission.)

Congenital biliary cysts



Five general forms of choledochal cyst found by cholangiography as originally described by Todani

Type I

EXCISION, ROUX-EN-Y HEPATICOJEJUNOSTOMY
EXCISION, HEPATICODUODENOSTOMY
Roux-en-Y choledochocysto-jejunostomy
Choledochocystoduodenostomy

Type II

EXCISION

Type III

TRANSDUODENAL EXCISION
Transduodenal sphincteroplasty
Endoscopic sphincterotomy

Type IVA

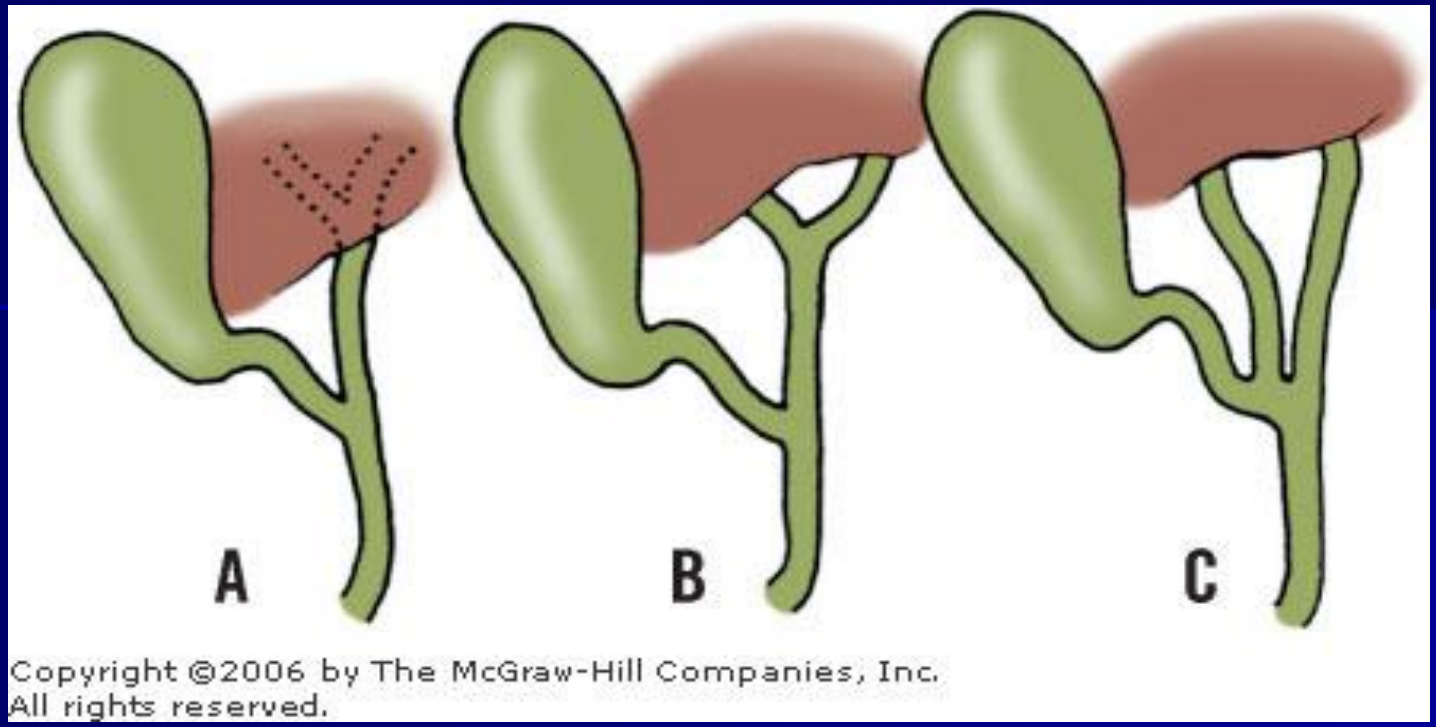
Extrahepatic component
EXCISION, ROUX-EN-Y HEPATICO-JEJUNOSTOMY
EXCISION, HEPATICODUODENOSTOMY
Intrahepatic component
Hepatic resection ± Roux-en-Y hepaticojejunostomy
Transhepatic intubation

Type IVB

EXCISION, ROUX-EN-Y HEPATICOJEJUNOSTOMY OR HEPATICODUODENOSTOMY
± transduodenal sphincteroplasty

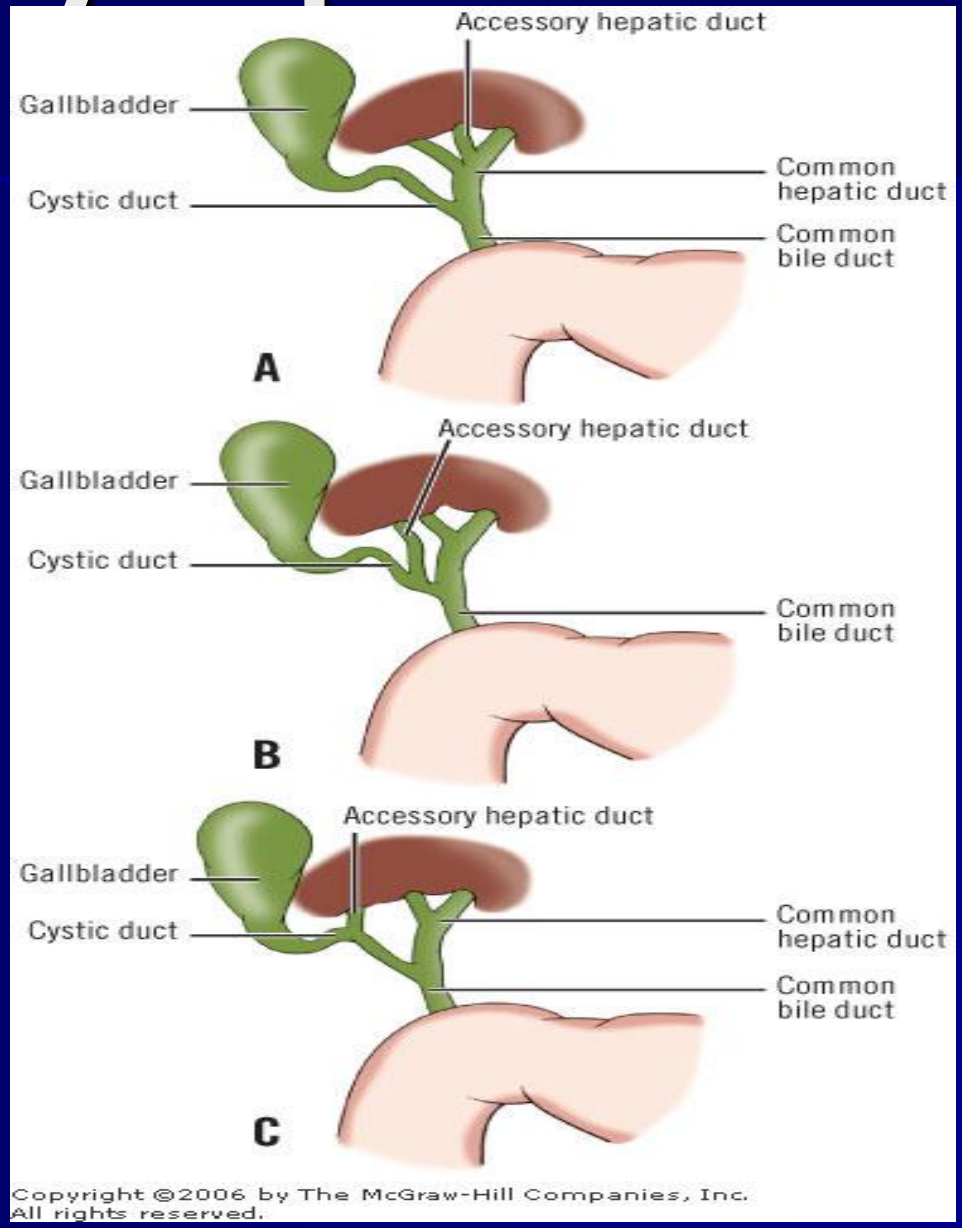
Type V
(Caroli's disease)

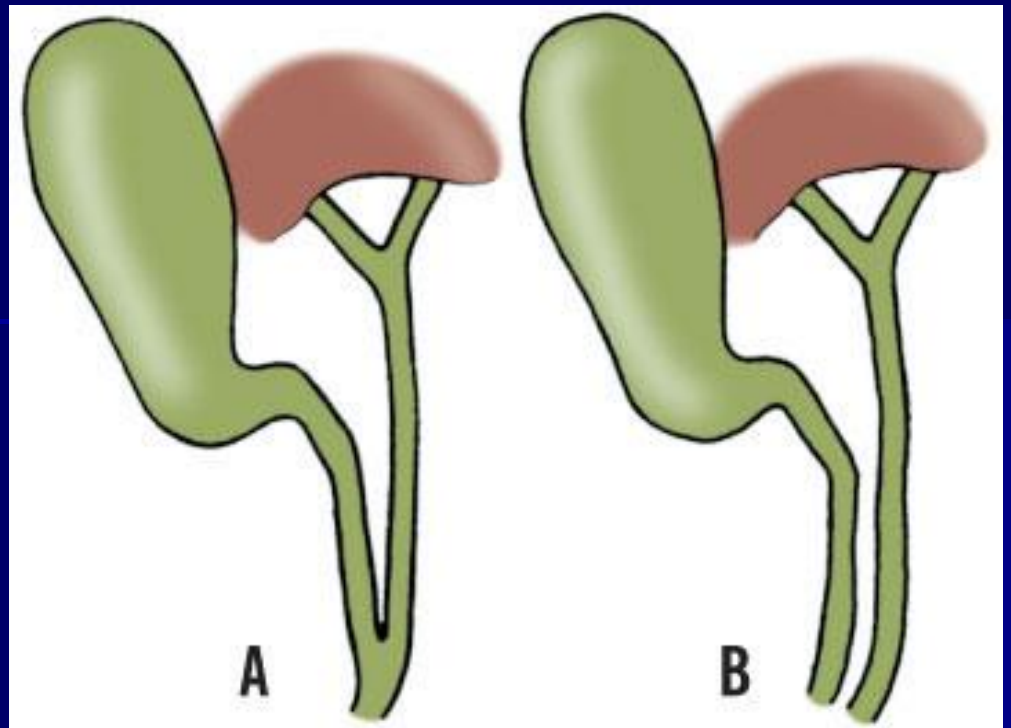
HEPATIC RESECTION
Roux-en-Y intrahepatic cholangiojejunostomy
Transhepatic intubation



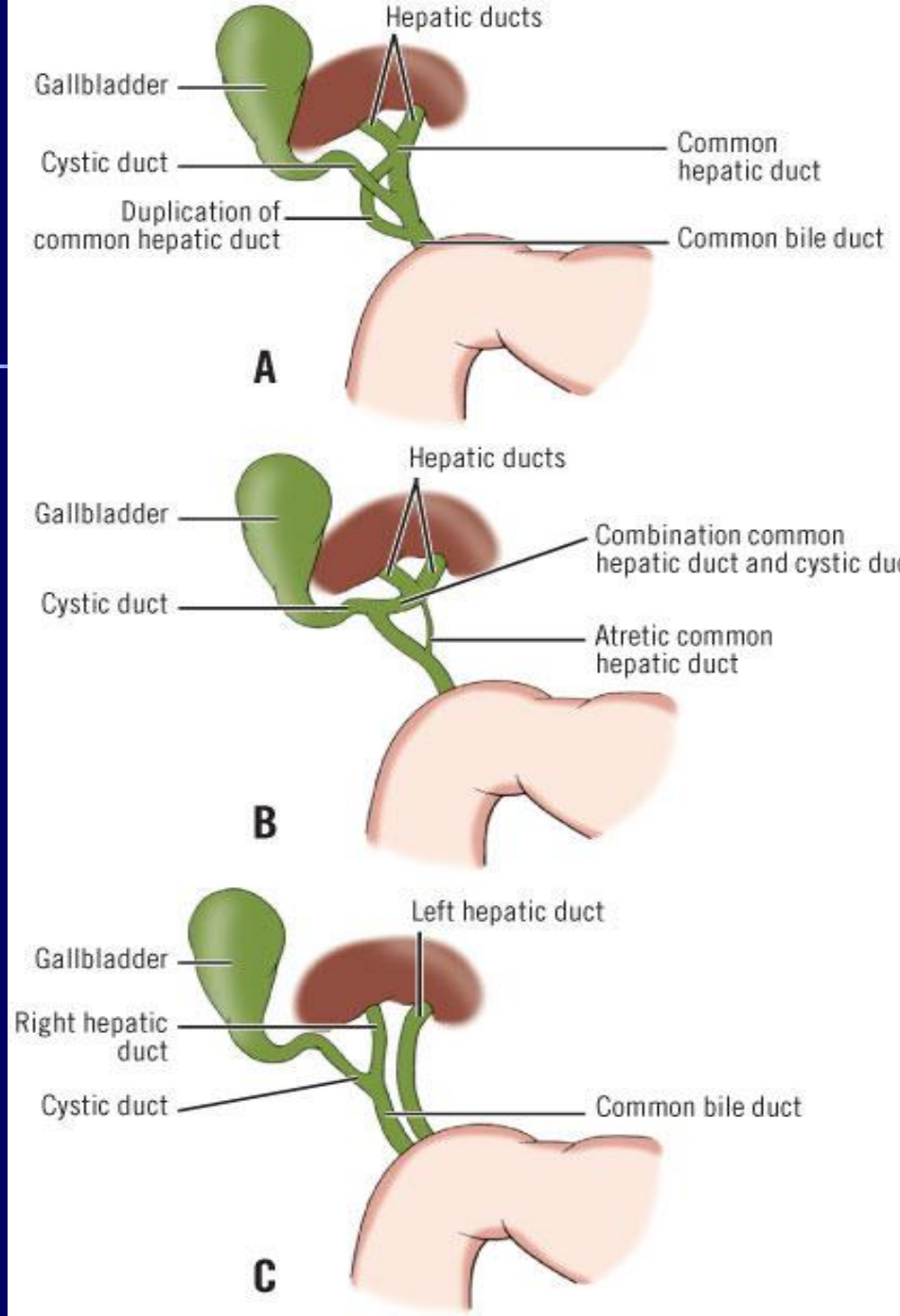
Variations of hepatic ducts. **A,** Intrahepatic union of right and left hepatic ducts. **B,** Extrahepatic (normal) union of hepatic ducts. **C,** Distal union of hepatic ducts resulting in absence of common hepatic duct. (Modified from Skandalakis JE, Gray SW. Embryology for Surgeons. 2nd ed. Baltimore: Williams & Wilkins, 1994; with permission.)

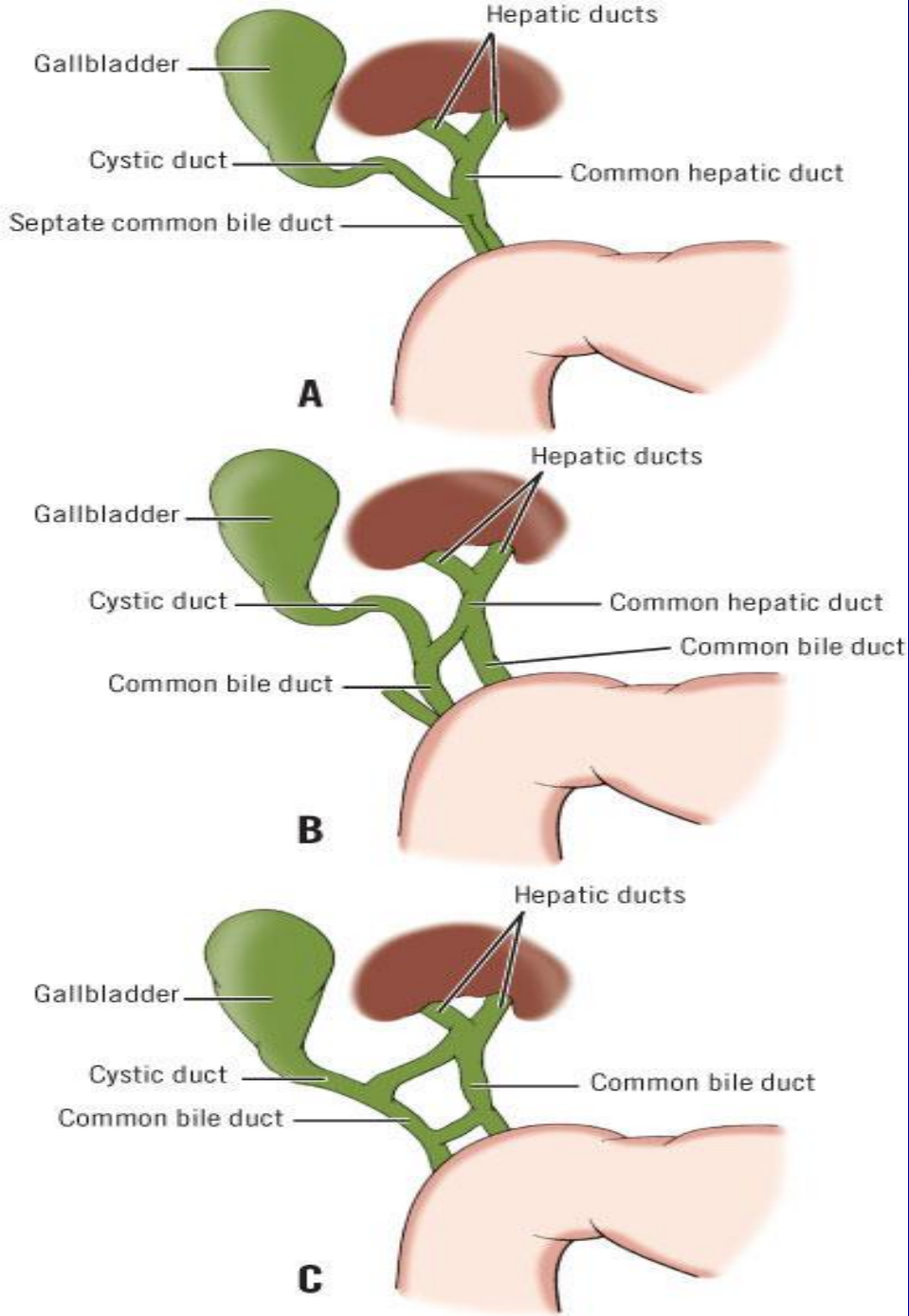
Accessory hepatic ducts.

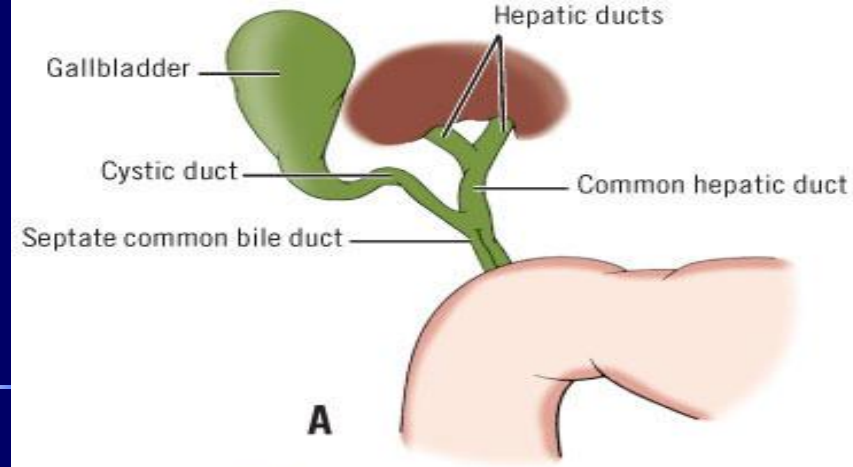


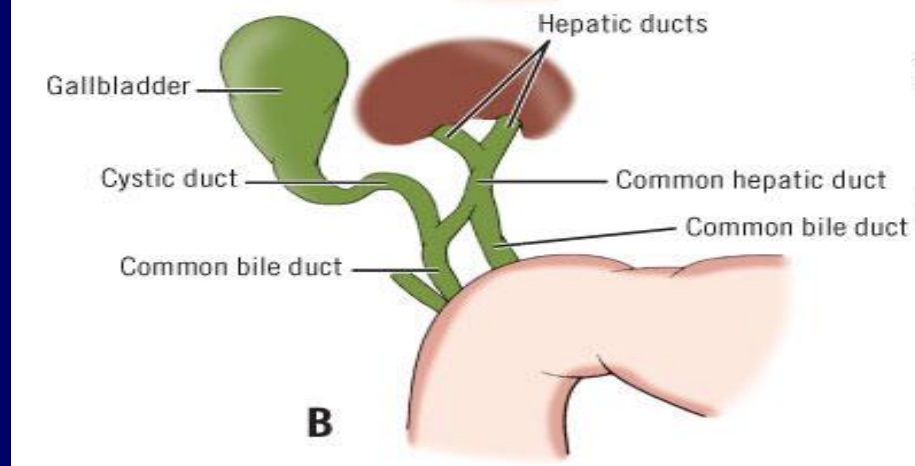


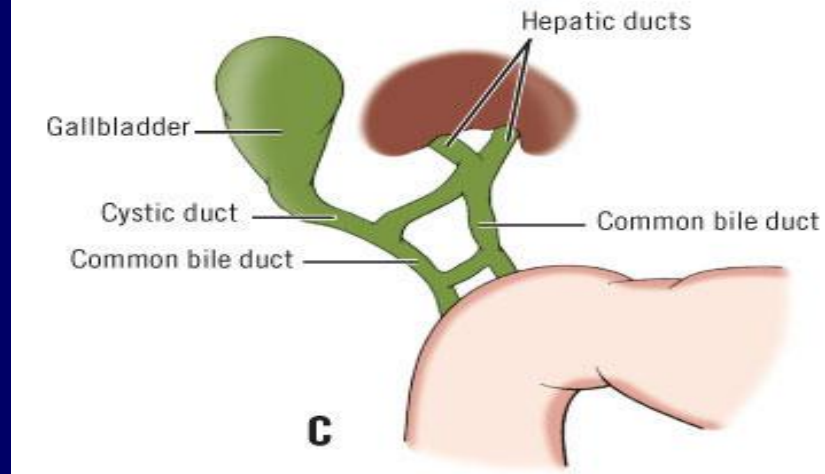
Variations of common bile duct. **A,** Low junction of cystic and common hepatic ducts results in shortened common bile duct. **B,** Absence of a common bile duct.

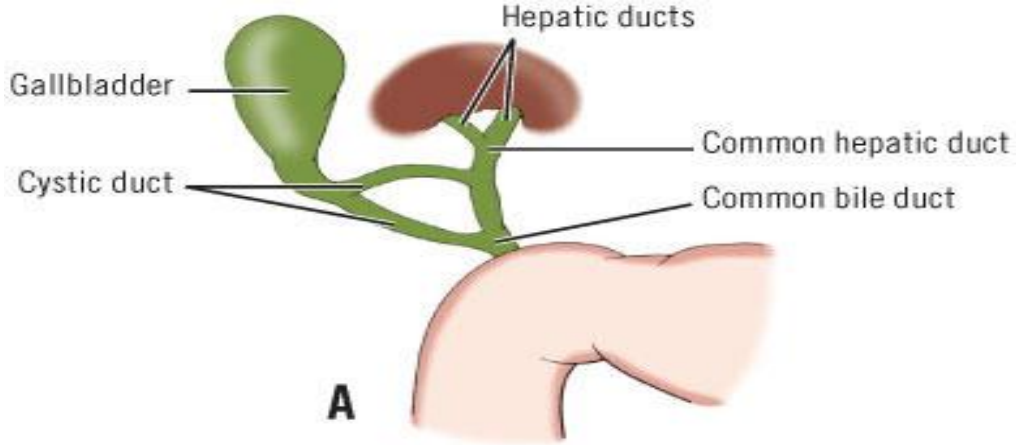


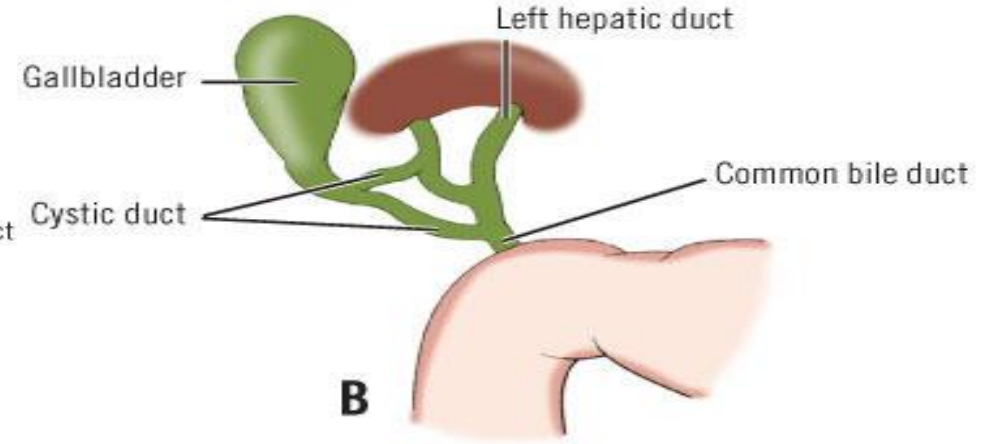


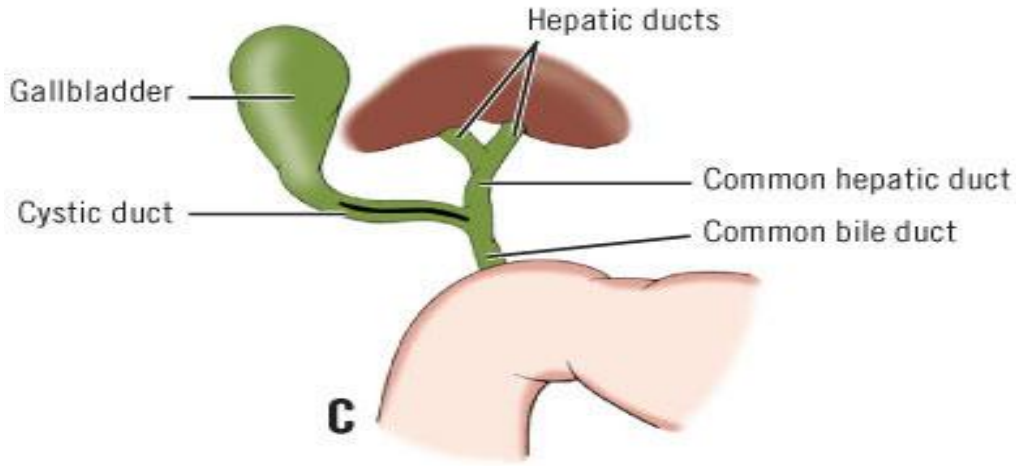


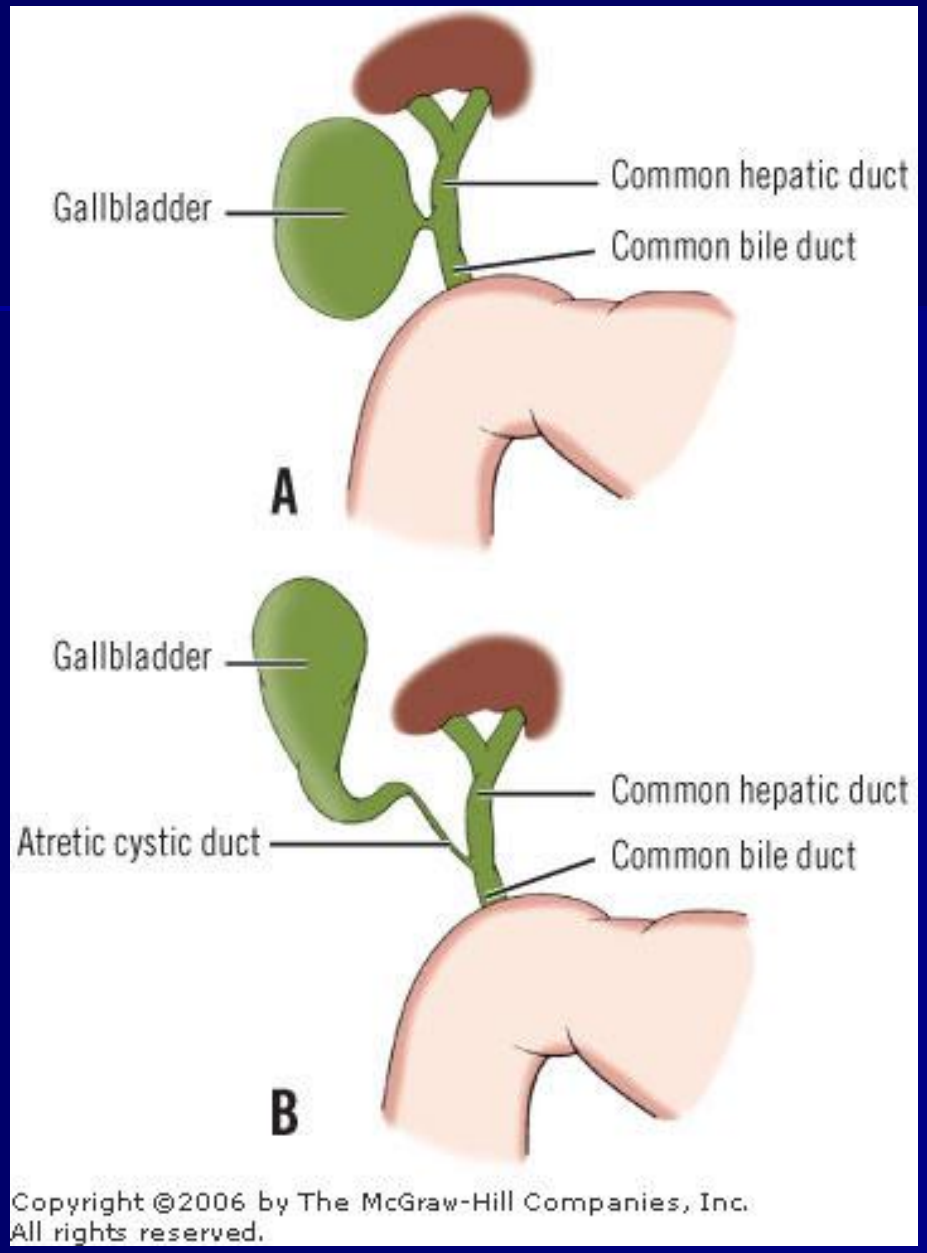










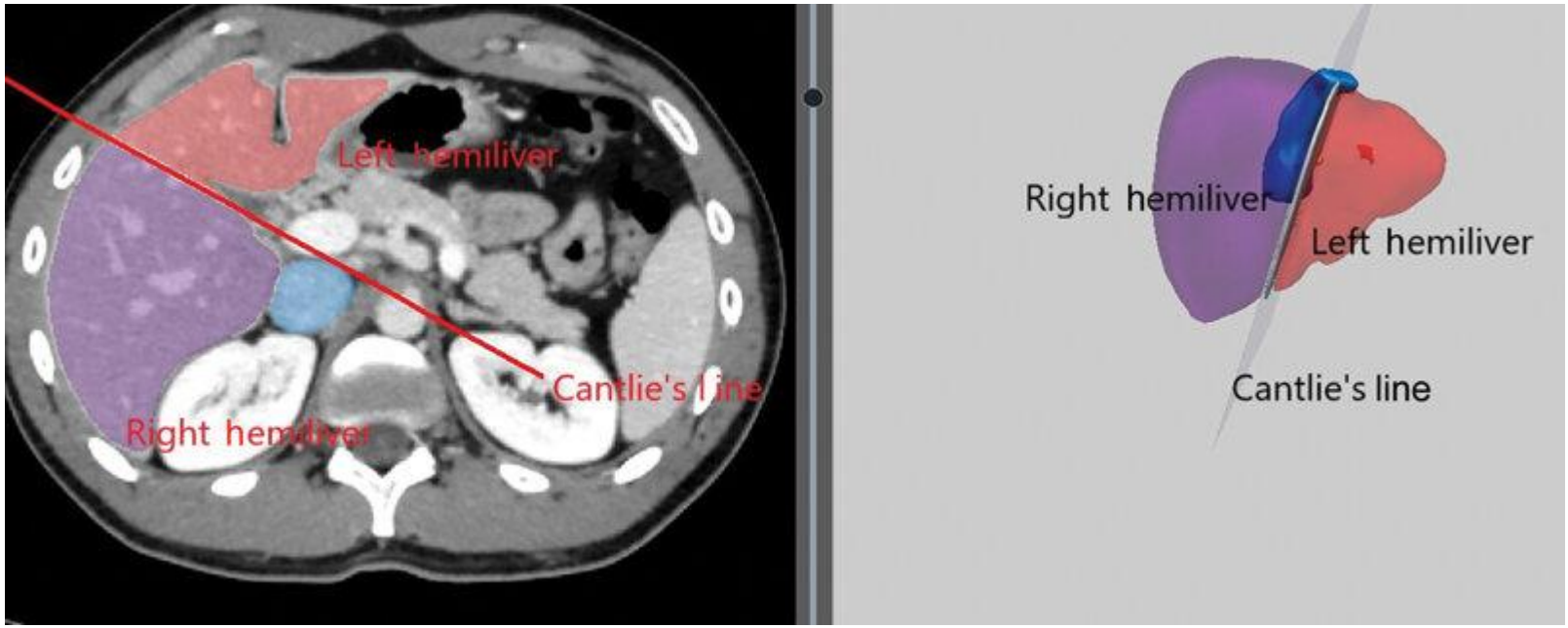


A, Absence of cystic duct, with sessile gallbladder. B, Atretic cystic duct with normal gallbladder.

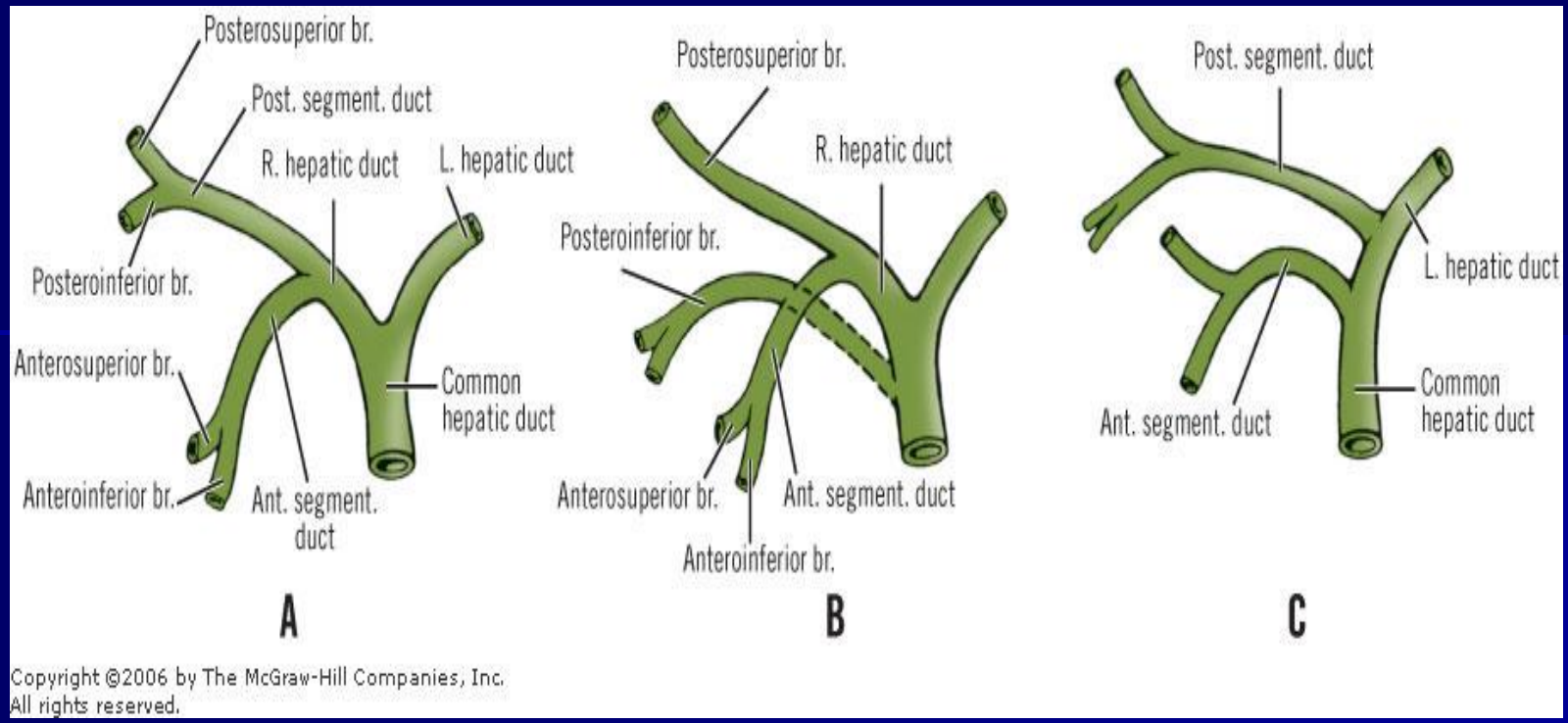
Surgical Anatomy

- In most cases, the portal vein, hepatic artery, and biliary duct are fellow travelers within the hepatic parenchyma.
- The hepatic veins do not follow the triad within the liver parenchyma: they pass between segments or subsegments.
- The triad is enveloped extrahepatically and intrahepatically by a thin fibrous sheath. This structure is a continuation of the endoabdominal fascia. Characteristically, the hepatic veins are not protected by this special envelope. This explains their tendency to tear easily. The connective tissue envelope also allows one to differentiate the former structures from hepatic veins by ultrasound and MRI (magnetic resonance imaging).
- The right hepatic vein can be exposed by division of the retrocaval ligament which connects segments I and VII.
- Lumbar veins do not enter the retrohepatic part of the IVC.
- The line of Rex (gallbladder to IVC) divides the liver into two equal functional lobes.
- There are no external landmarks for the division created by the line of Rex.
- There is confusion in the literature about the true anatomy of the quadrate and caudate lobes. All the various opinions may be correct from a surgical standpoint. However, in a right functional lobectomy, large parts of both the caudate and the quadrate lobes are transected. For all practical purposes, the caudate lobe (segment I) belongs to both the right and left functional lobes. The quadrate lobe belongs to the medial segment of the left lobe (segment IV).

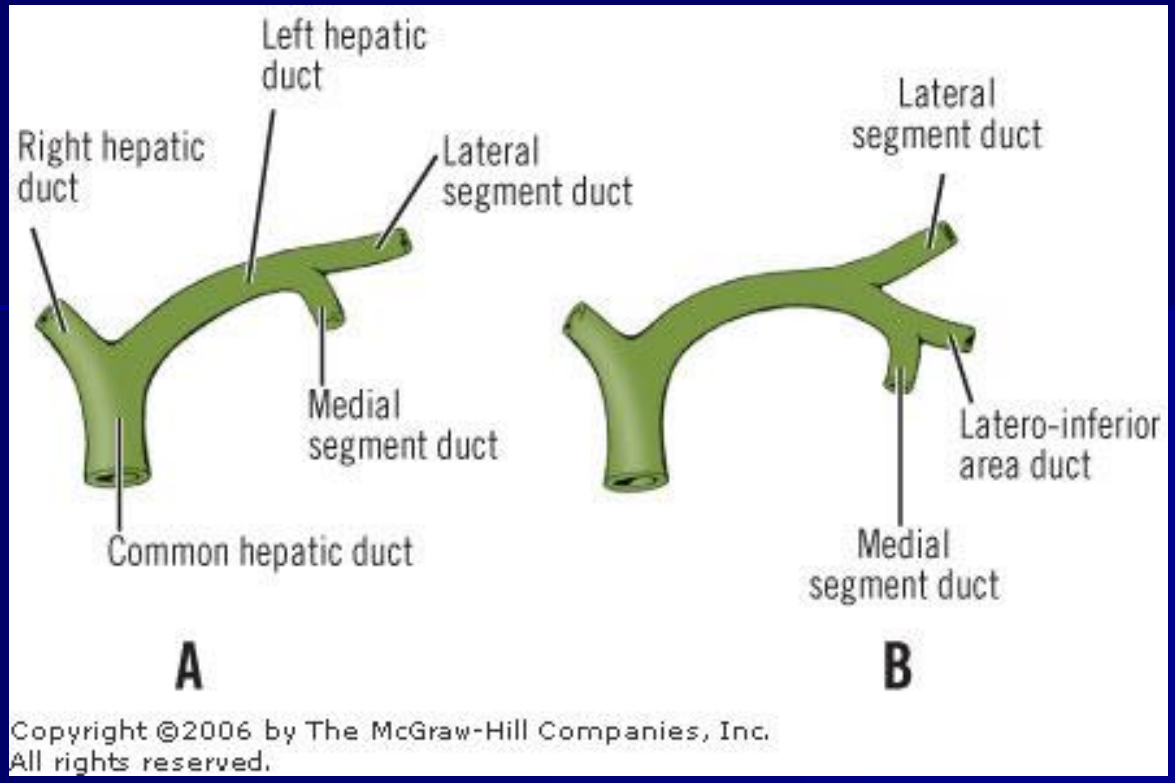
Cantlie line



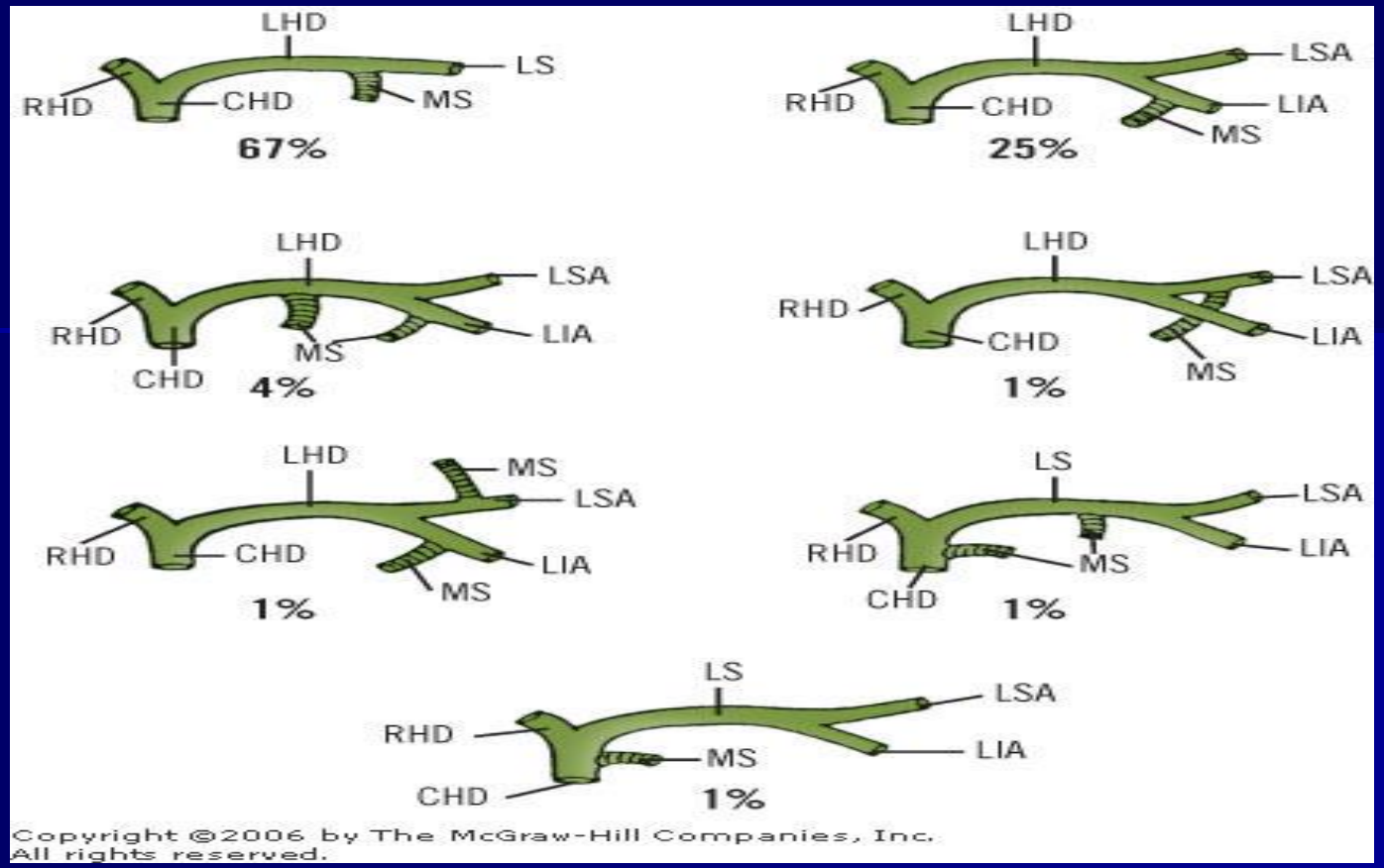
Vertical plane that divides the liver into left and right lobes creating the principal plane used for hepatectomy. It extends from the inferior vena cava posteriorly to the middle of the gallbladder fossa anteriorly



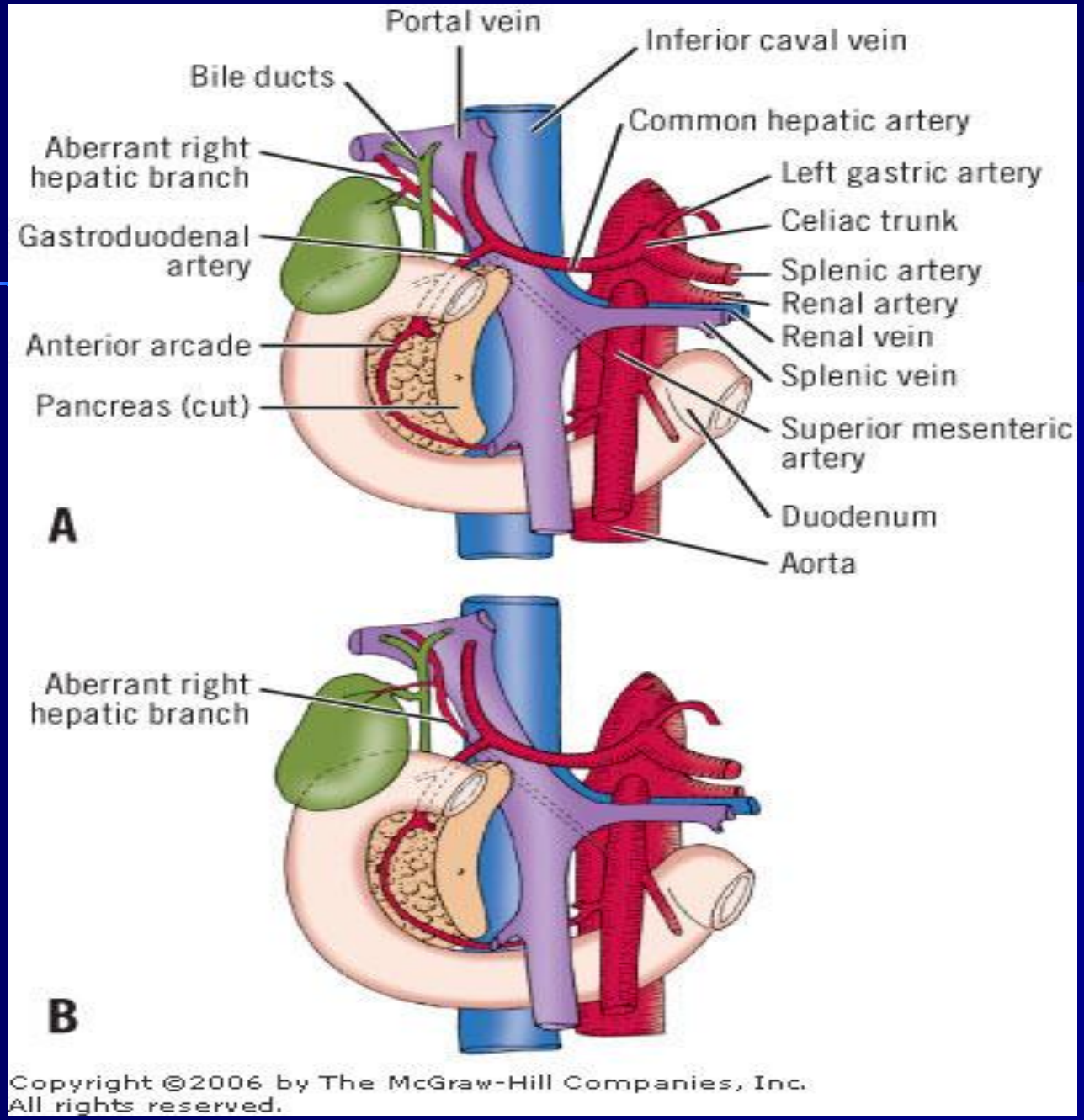
Variations in tributaries to right hepatic duct. **A,** Usual pattern. Right hepatic duct receives anterior and posterior segment ducts. **B,** Alternate pattern. Posteroinferior area duct enters common hepatic duct. **C,** Anterior and posterior segment ducts enter left hepatic duct. Right hepatic duct absent.



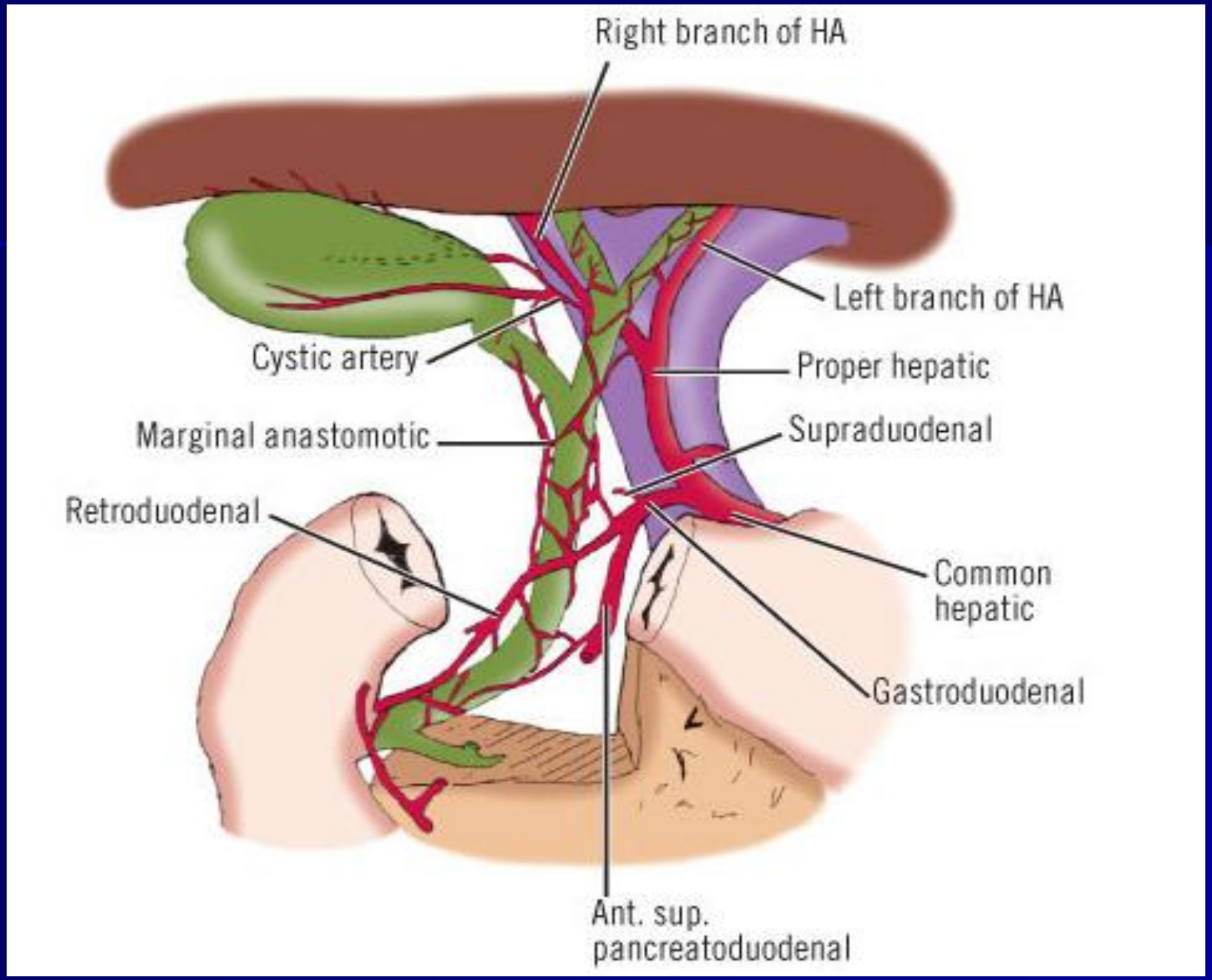
Variations of left hepatic duct. **A,** Usual pattern. Left hepatic duct forms by confluence of medial and lateral segment ducts. **B,** Medial segment duct may enter inferolateral duct. Medial segment duct is usually double. (Modified from Colborn GL, Skandalakis LJ, Gray SW, Skandalakis JE. Surg 1987;30 (6):15-23; with permission.)

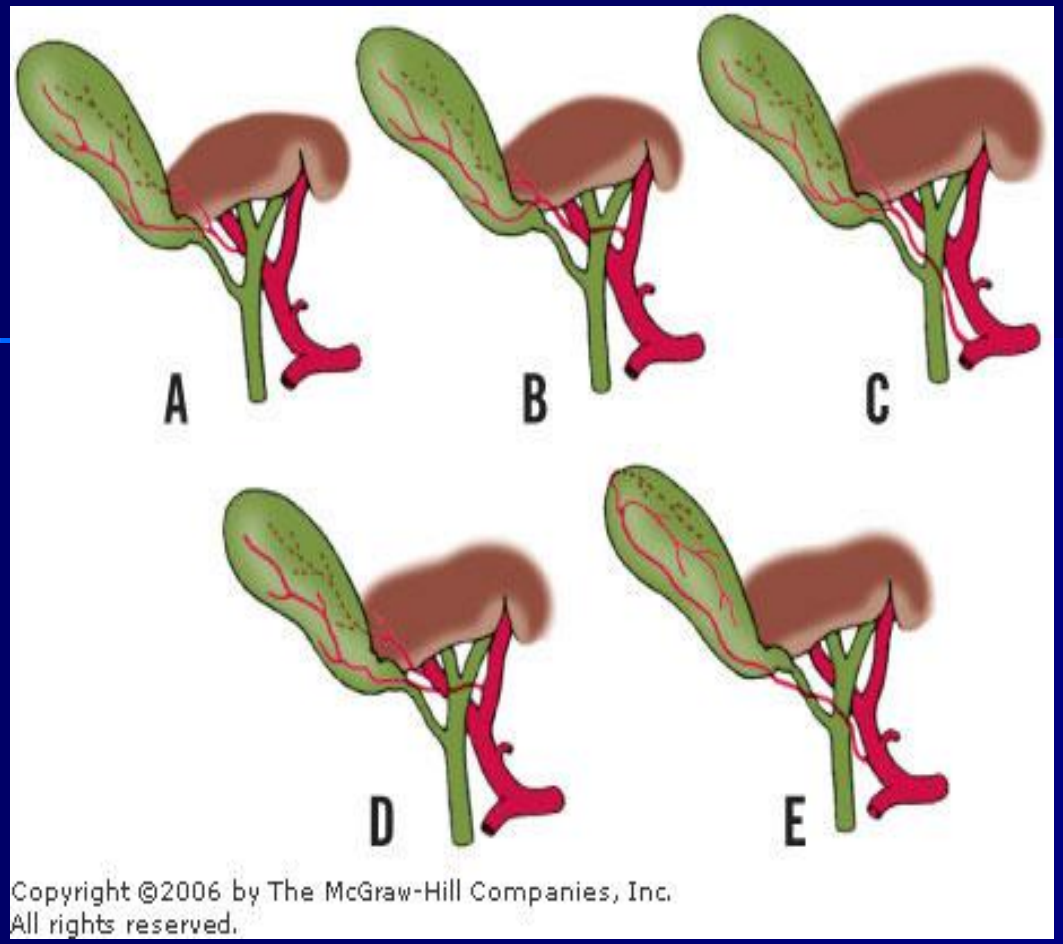


Variations of sites of drainage of medial segment duct. CHD, Common hepatic duct; RHD, Right hepatic duct; LHD, Left hepatic duct; LS, Lateral segment duct; MS, Medial segment duct; LSA, Lateral superior area duct; LIA, Lateral inferior area duct.

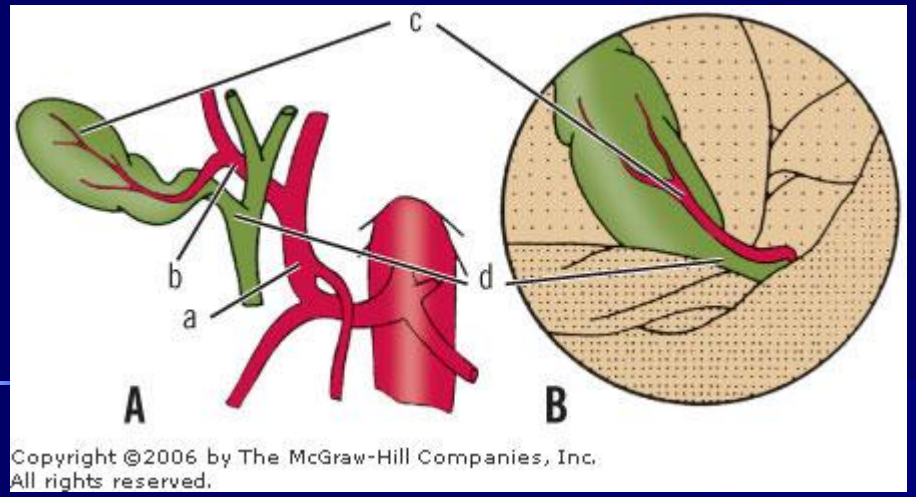


Aberrant right hepatic branch from superior mesenteric artery runs behind pancreas and behind portal vein. A, Branch appears in intercholedochohepatic area and continues behind choledochus. B, Same branch turns upward to run upon portal vein, behaving like normal right hepatic branch.


Right branch of HA
Left branch of HA
Cystic artery
Proper hepatic
Marginal anastomotic
Supraduodenal
Retroduodenal
Common hepatic
Gastroduodenal
Ant. sup. pancreatoduodenal

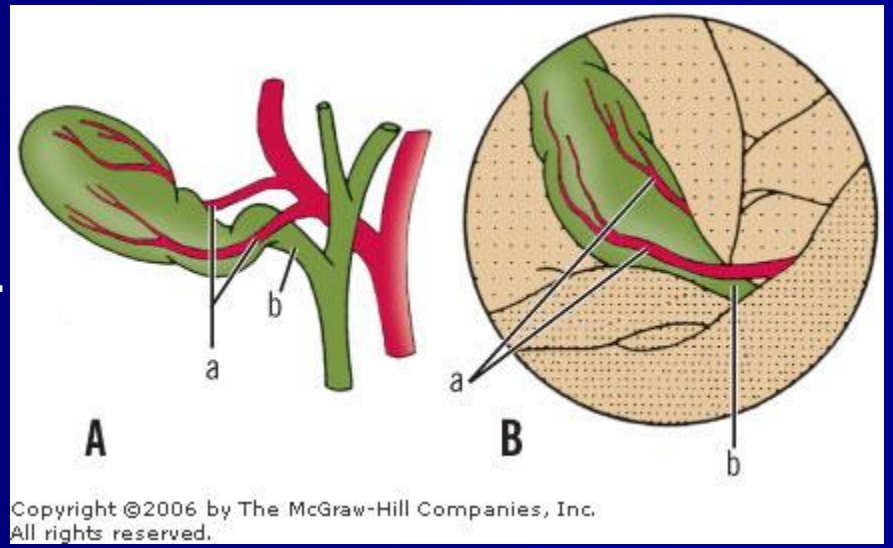


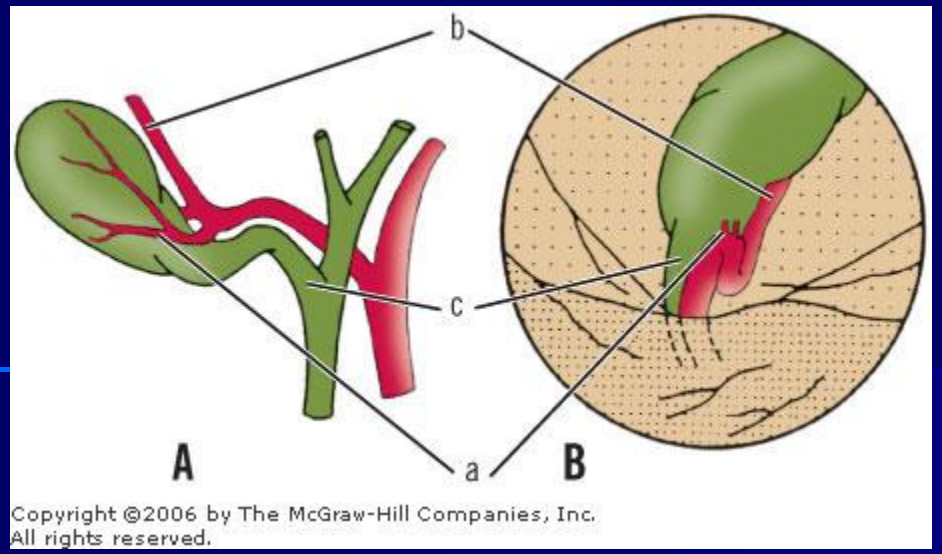
Variations of origin and course of cystic artery. A, Cystic artery arises from right hepatic artery (74.7%). B, Cystic artery arises from left hepatic artery and passes anterior to common hepatic duct (20.5%). C, Cystic artery arises from gastroduodenal artery (2.5%). D-E, Recurrent cystic arteries reach fundus of gallbladder and descend toward neck (rare). In the remainder (approximately 2.3%, not shown), cystic artery arises from a variety of other arteries



Normal position of the cystic artery. **A,** Conventional visualization. **B,** Laparoscopic visualization. a, Common hepatic artery; b, Right hepatic artery; c, Cystic artery; d, Cystic duct.

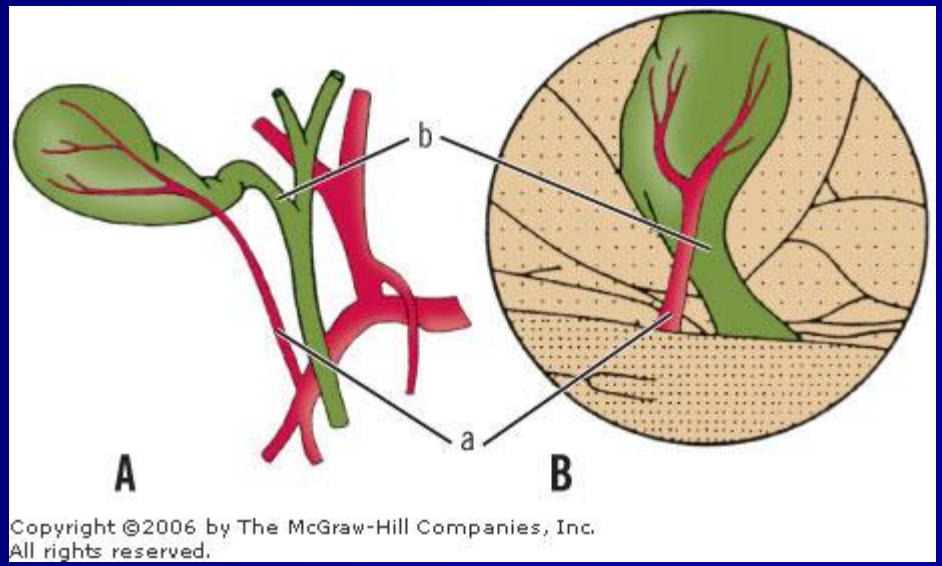
Double cystic artery. **A,** Conventional visualization. **B,** Laparoscopic visualization. a, Double cystic arteries; b, Cystic duct.

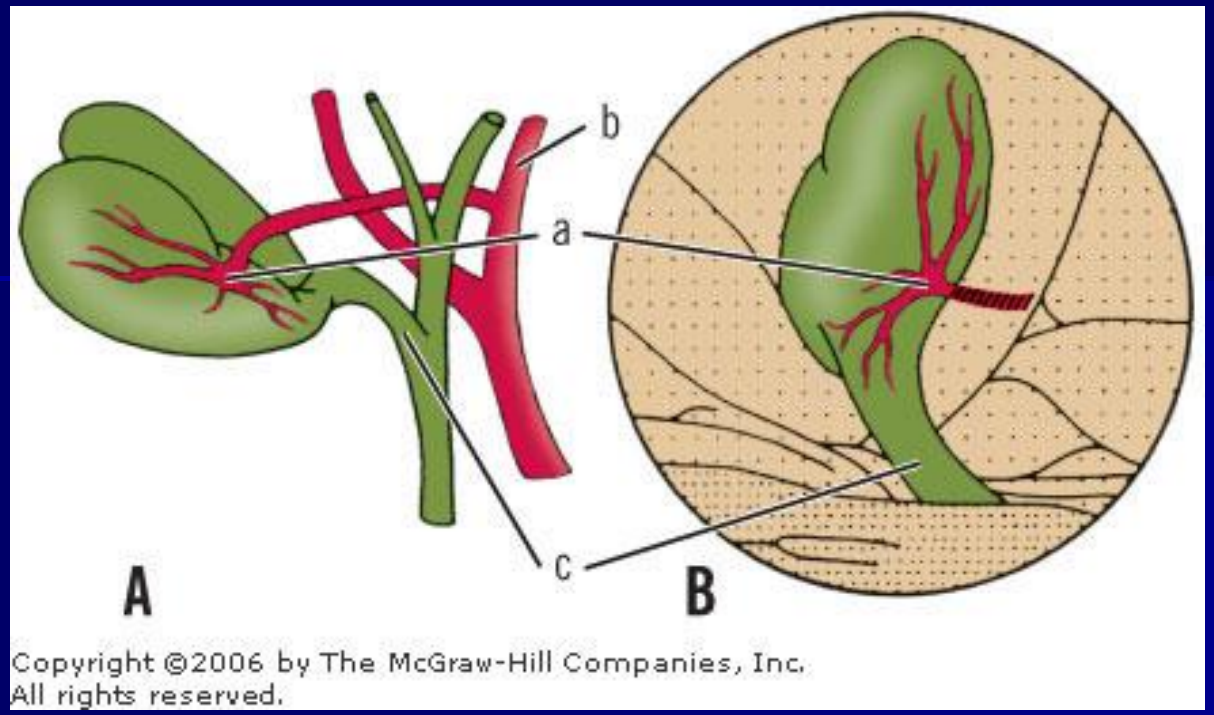




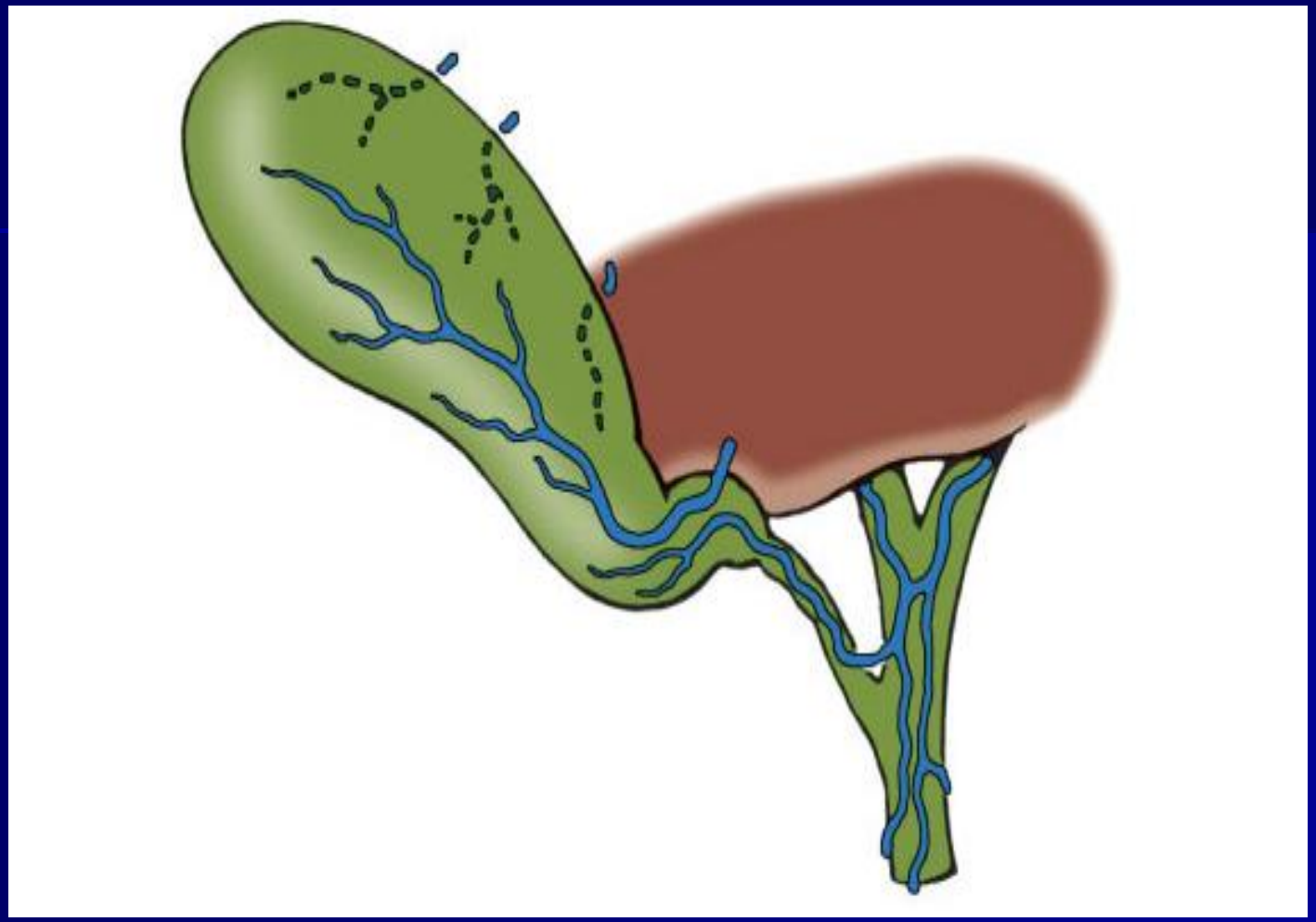
"Large cystic artery." A, Conventional visualization. B, Laparoscopic visualization. a, Cystic artery (or cystic arteries); b, Aberrant right hepatic artery; c, Cystic duct.

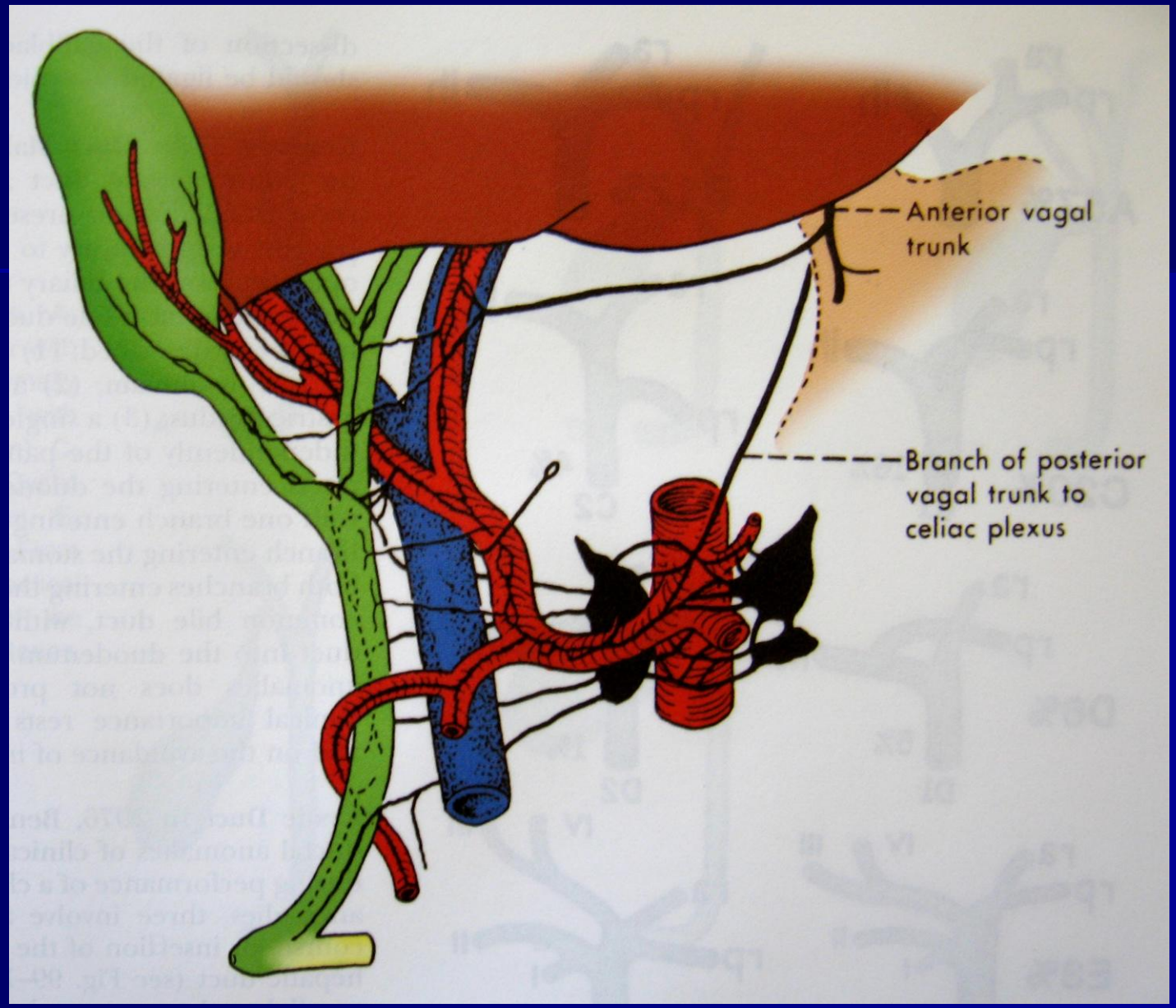
Cystic artery originating from the gastroduodenal artery. **A,** Conventional visualization. **B,** Laparoscopic visualization. a, Cystic artery; b, Cystic duct.

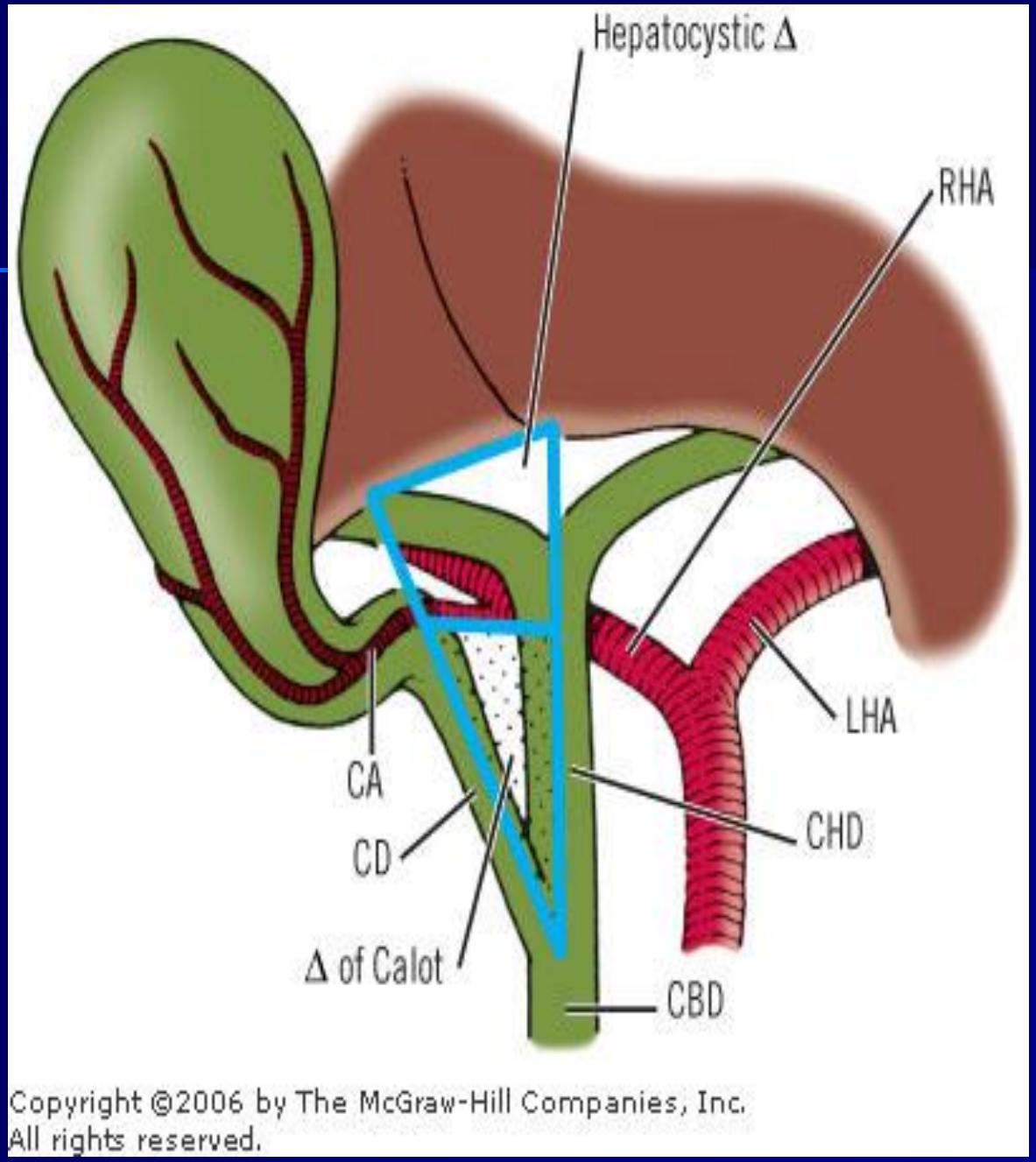




Cystic artery originating from the left hepatic artery. A, Conventional visualization. B, Laparoscopic visualization. a, Cystic artery originating from the left hepatic artery; b, Left hepatic artery; c, Cystic duct. (Modified from Balija M, Huis M, Nikolić V, Štulhofer M. Laparoscopic visualization of the cystic artery anatomy. World J Surg 1999;23:703-707; with permission.)

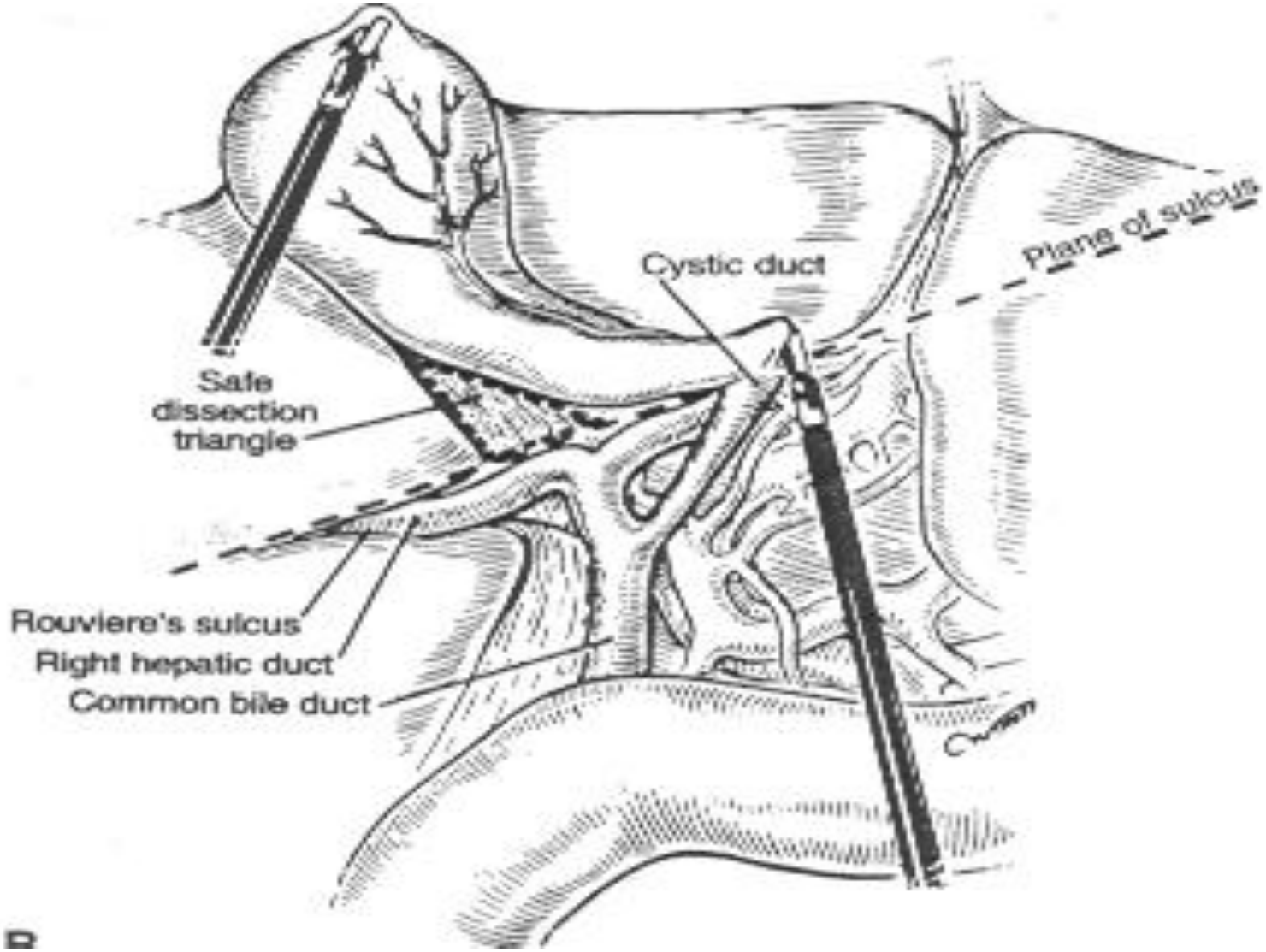



Anterior vagal trunk
Branch of posterior vagal trunk to celiac plexus

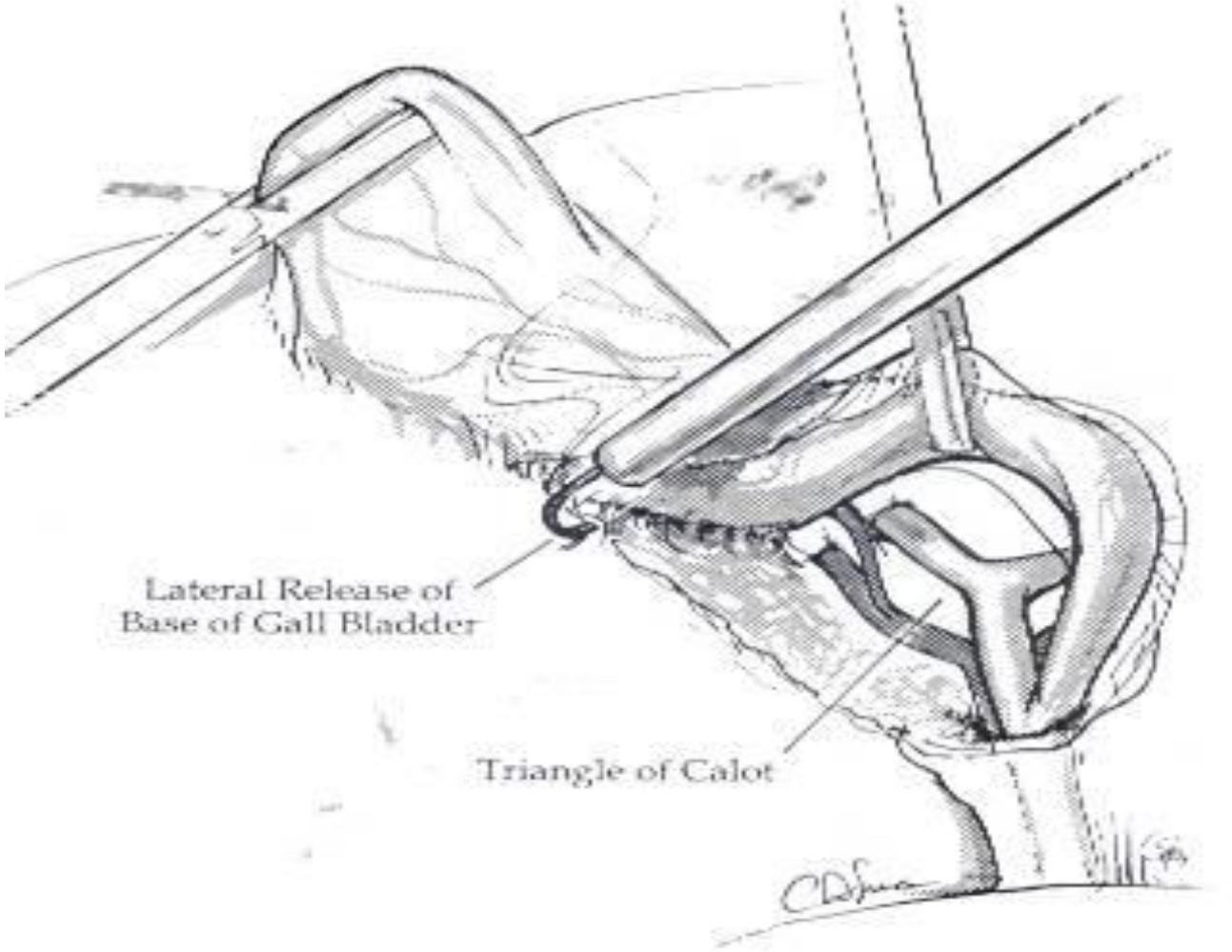


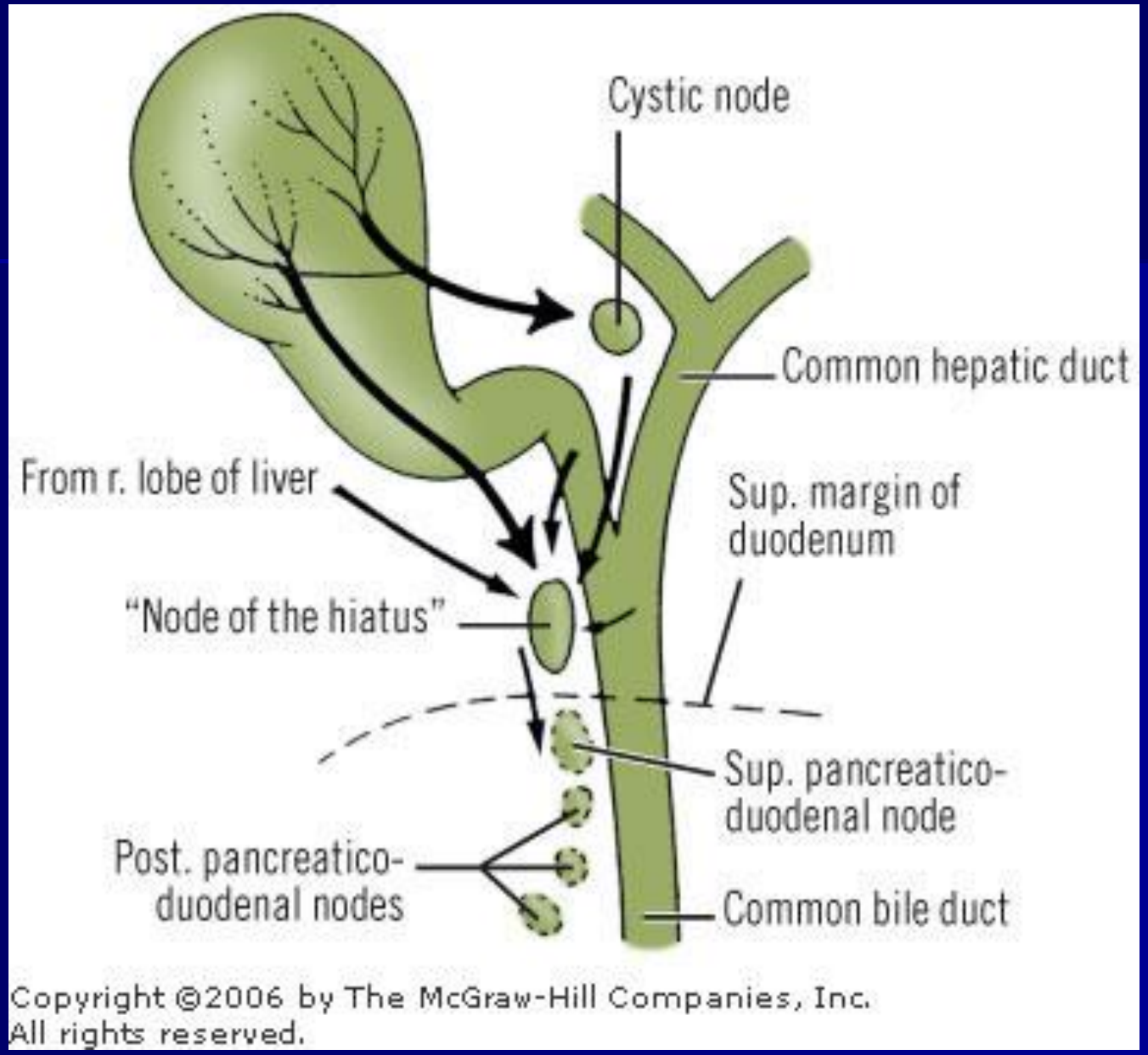
Hepatocystic triangle and triangle of Calot. Upper boundary of hepatocystic triangle is inferior border of liver. CA, Cystic artery. CD, Cystic duct. CHD, Common hepatic duct. CBD, Common bile duct. LHA/RHA, Left and right hepatic arteries. (Modified from Skandalakis JE, Gray SW, Rowe JS Jr. Anatomical Complications in General Surgery. New York: McGraw-Hill, 1983; with permission.)

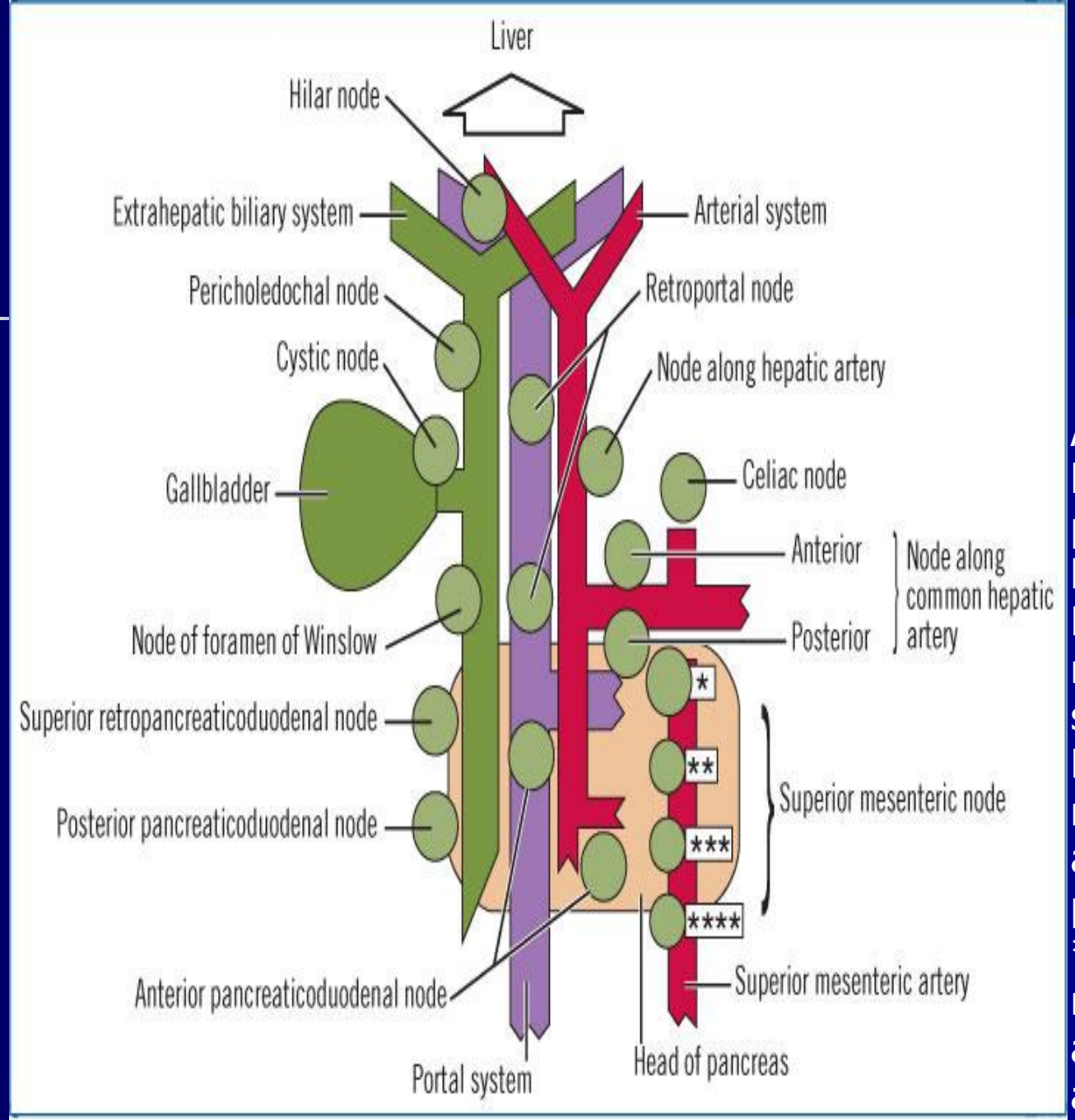
“critical view”



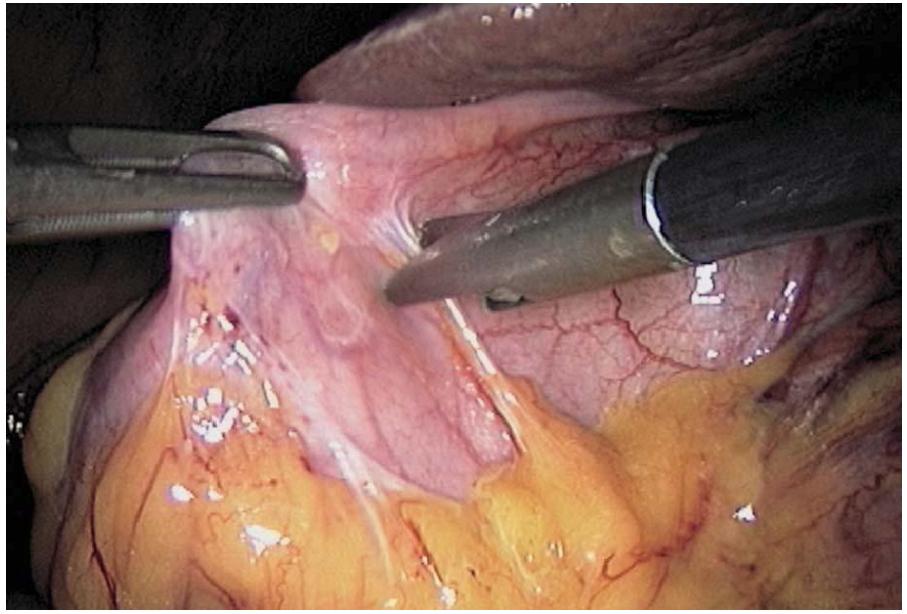
“critical view”

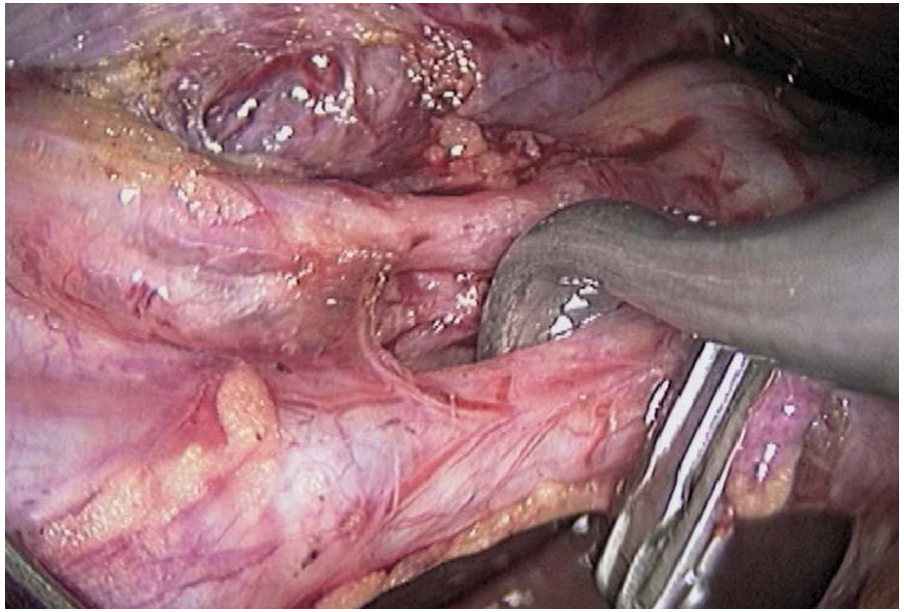


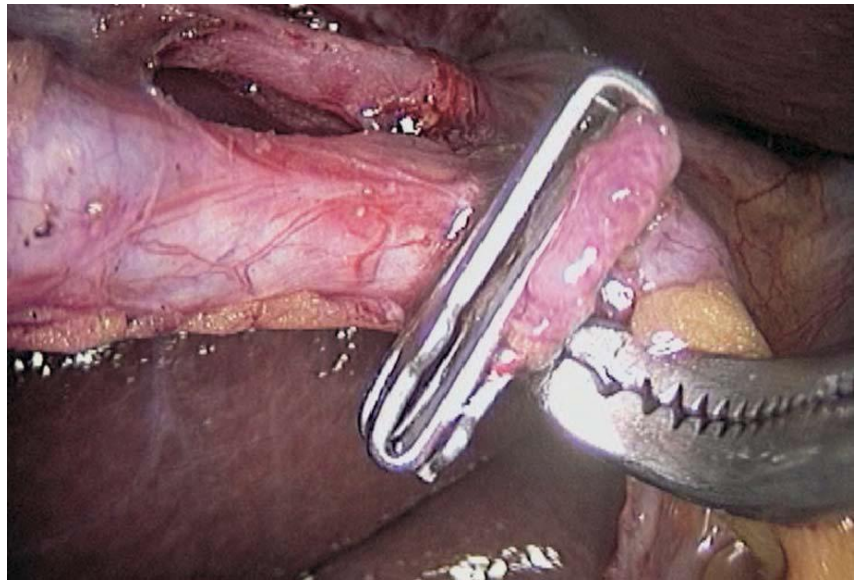


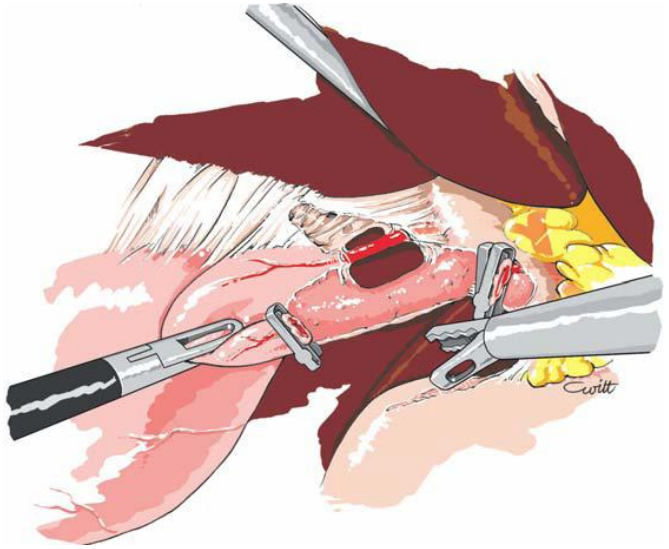


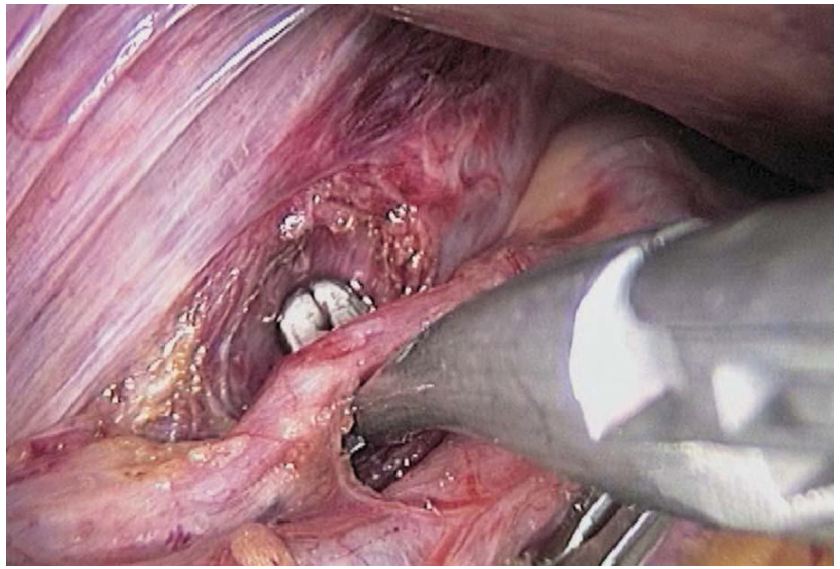
Anatomic configuration of lymph nodes around head of pancreas and in hepatoduodenal ligament. Nodes along superior mesenteric artery are subdivided into four groups: * Node near origin of superior mesenteric artery; ** Node around origin of inferior pancreaticoduodenal artery; *** Node around origin of middle colic artery; **** Node around origin of first jejunal artery.

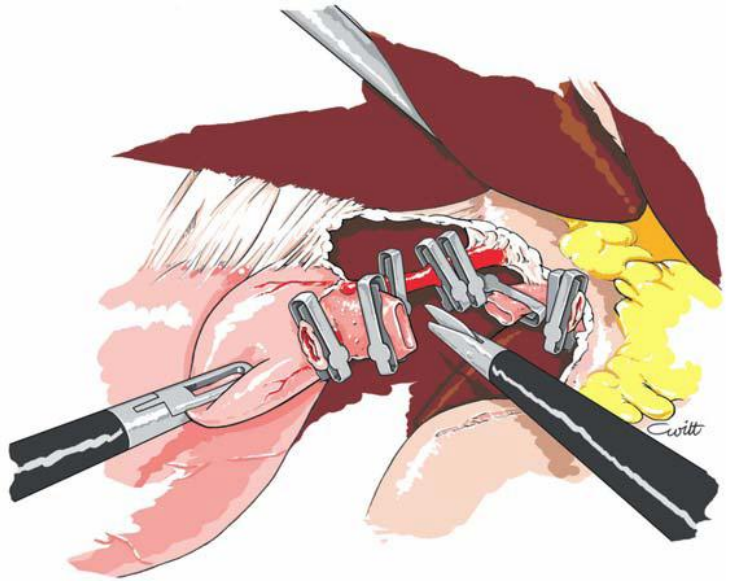


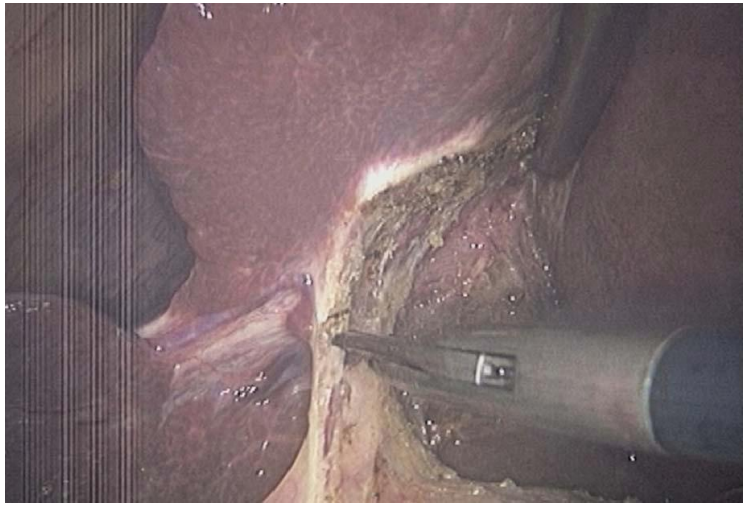


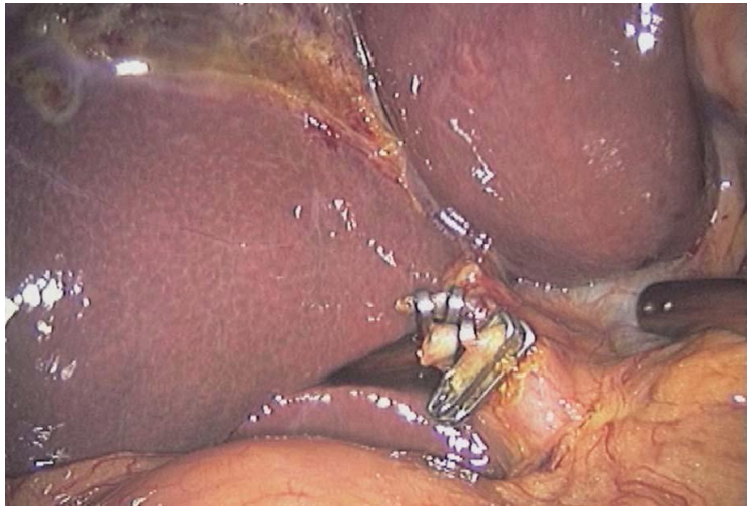


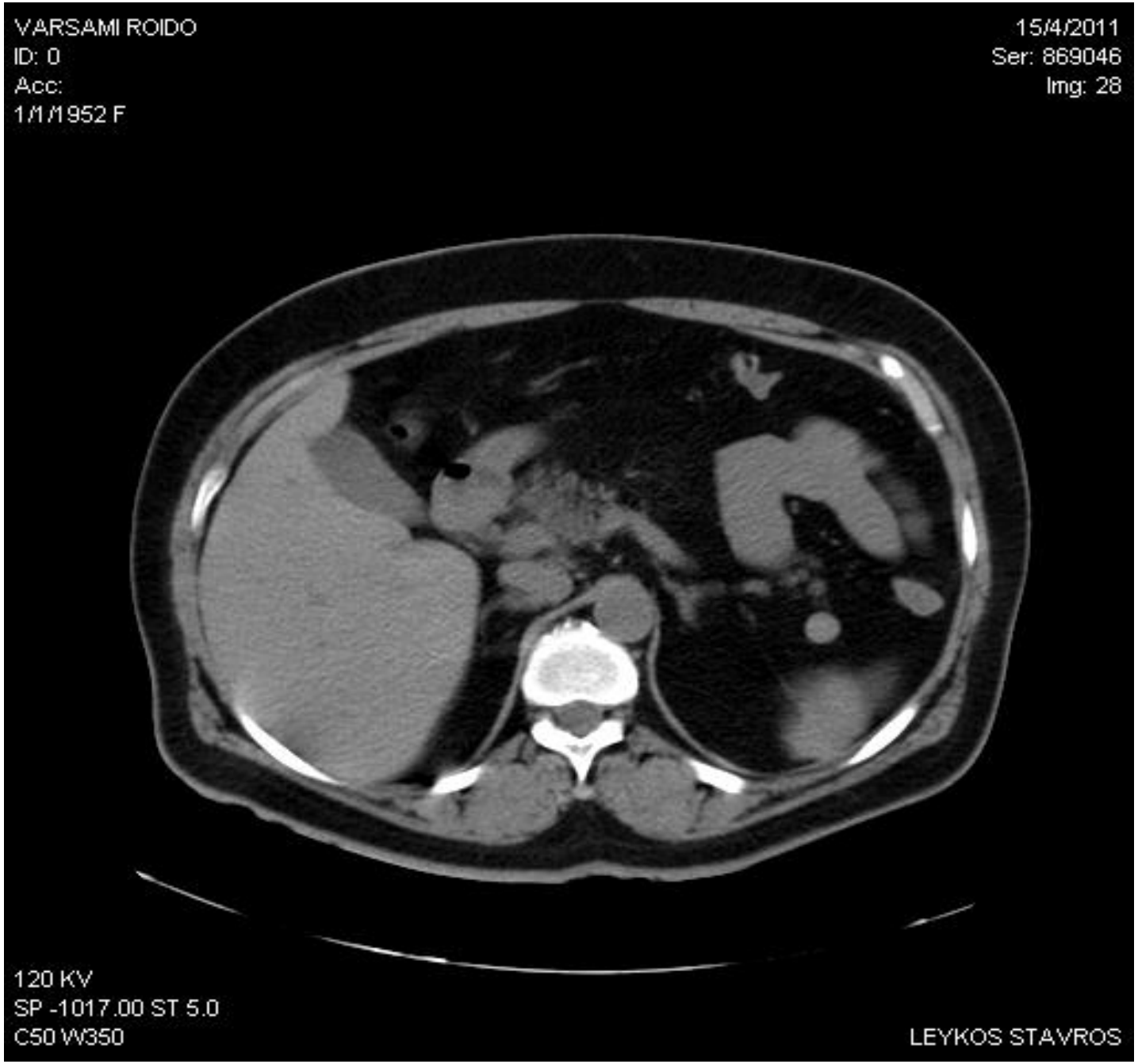








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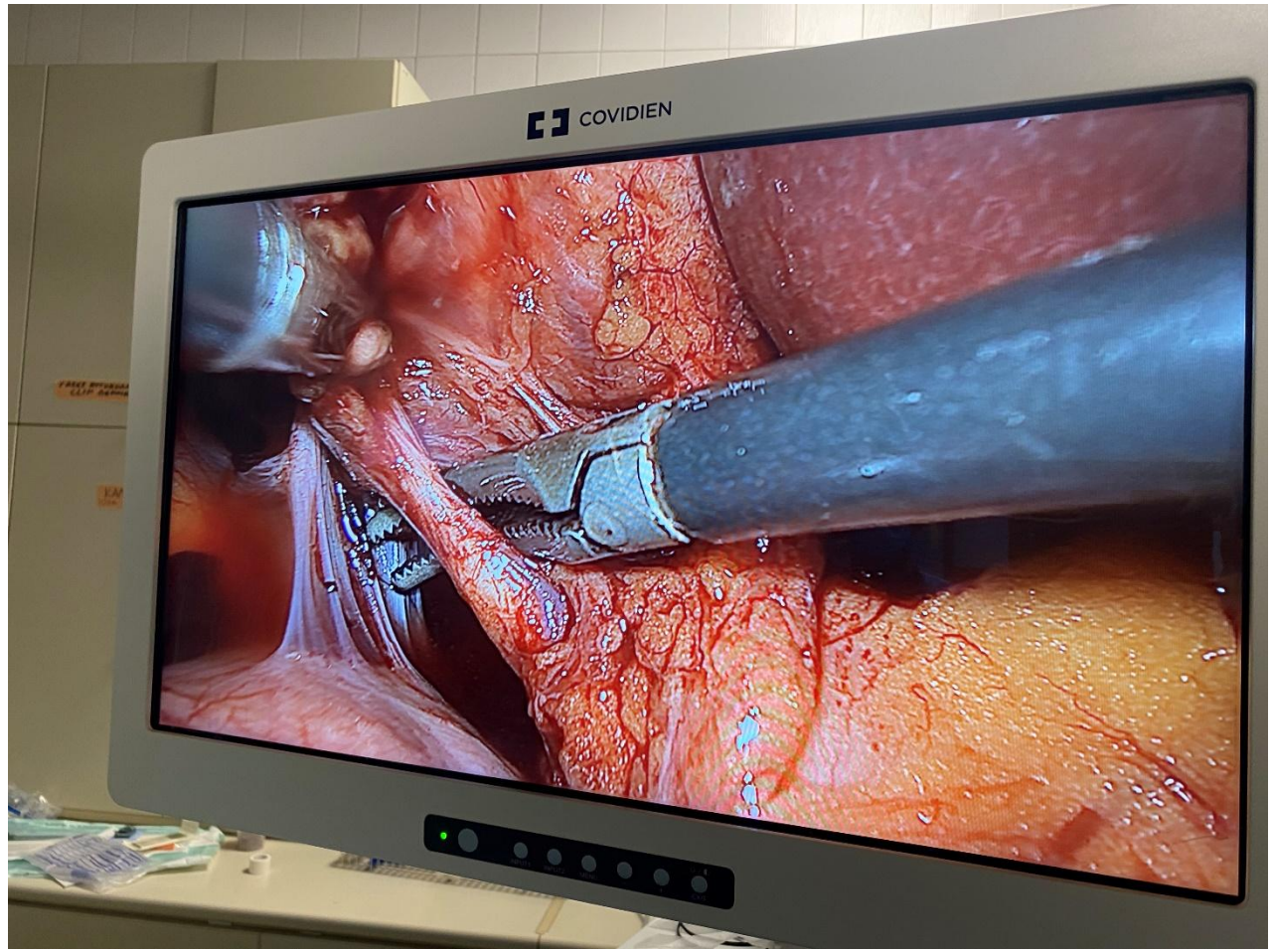
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Anatomy Research International
Volume 2015, Article ID 847812, 3 pages
http://dx.doi.org/10.1155/2015/847812

Research Article

Artery to Cystic Duct: A Consistent Branch of Cystic Artery Seen in Laparoscopic Cholecystectomy

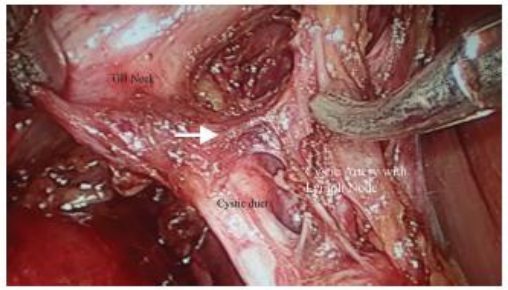


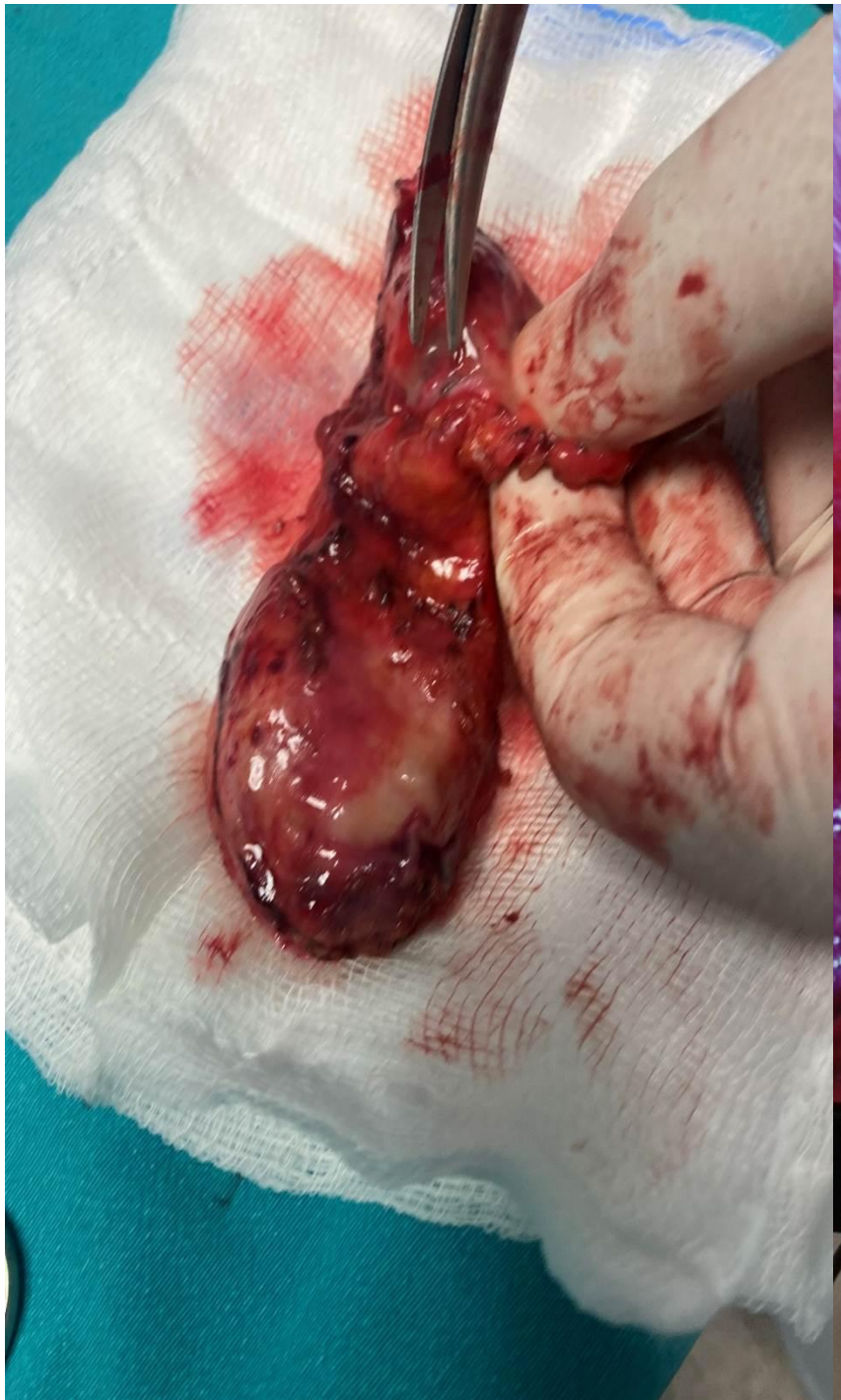
FIGURE 1: The "*H-configuration*" showing cystic artery, cystic duct, and the artery to cystic duct (white arrow). The GB neck, the CBD, and the cystic Lymph node of Lundt are also shown.

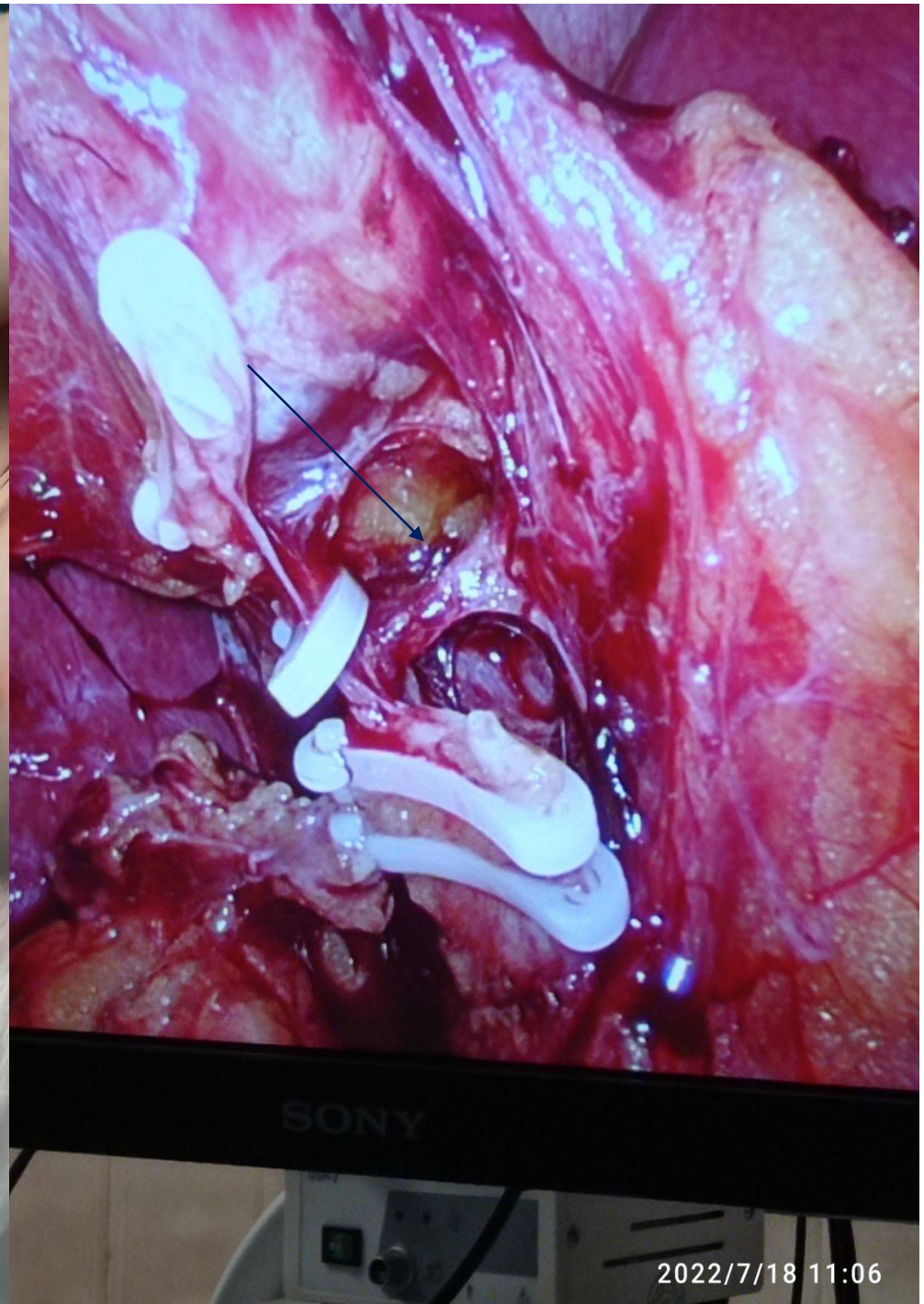
References

[1] T. B. Hugh, M. D. Kelly, and A. Mekisic, "Rouviere's sulcus: a useful landmark in laparoscopic cholecystectomy," *British Journal of Surgery*, vol. 84, no. 9, pp. 1253–1254, 1997.

1981.

[15] T. B. Hugh, M. D. Kelly, and B. Li, "Laparoscopic anatomy of the cystic artery," *The American Journal of Surgery*, vol. 163, no. 6, pp. 593–595, 1992.

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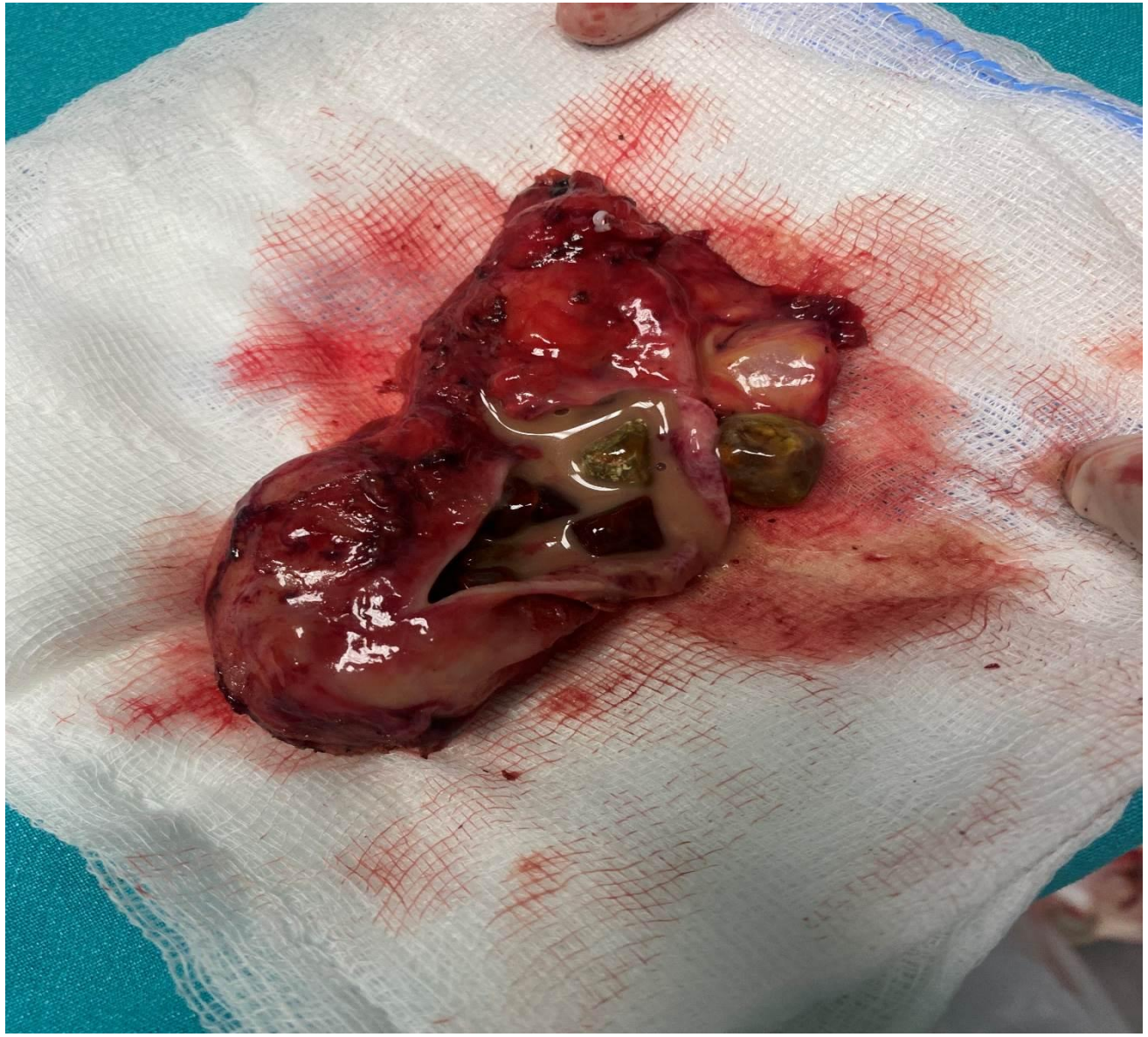
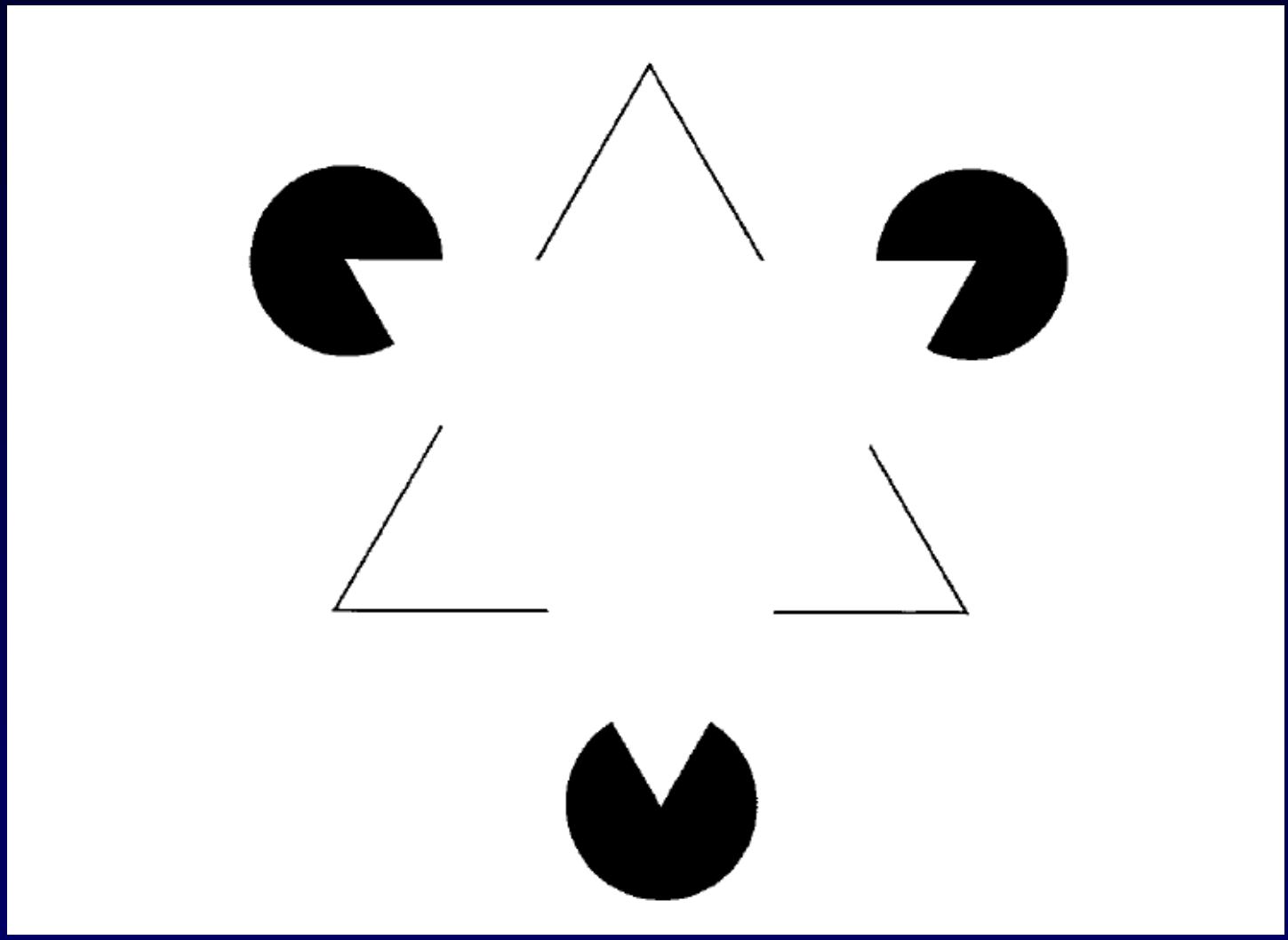




Perception may be faulty and beyond the individual’s knowledge and control

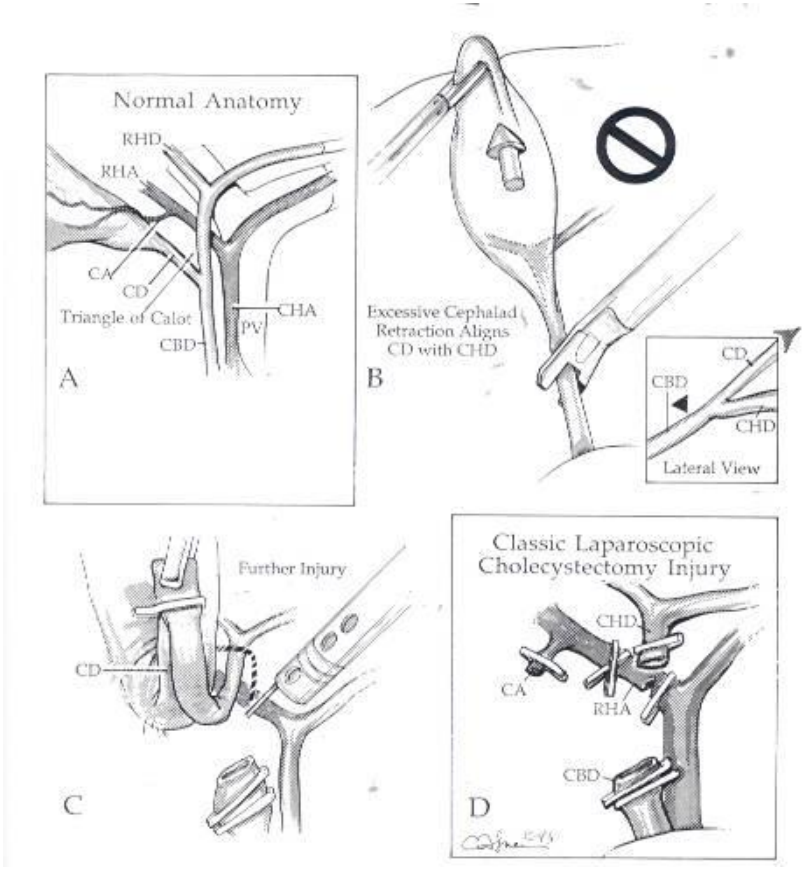
The problem

“... a Keyhole scar and catastrophe within.”

Lord Smith BMJ 1991

Bile Duct Injury

"Infundibular" technique



The problem

- 4%

  Way LW. Ann Surg 1992

- 0.3 – 0.8%

  Strasberg SM, J Hepatobil Pancreat Surg 2002

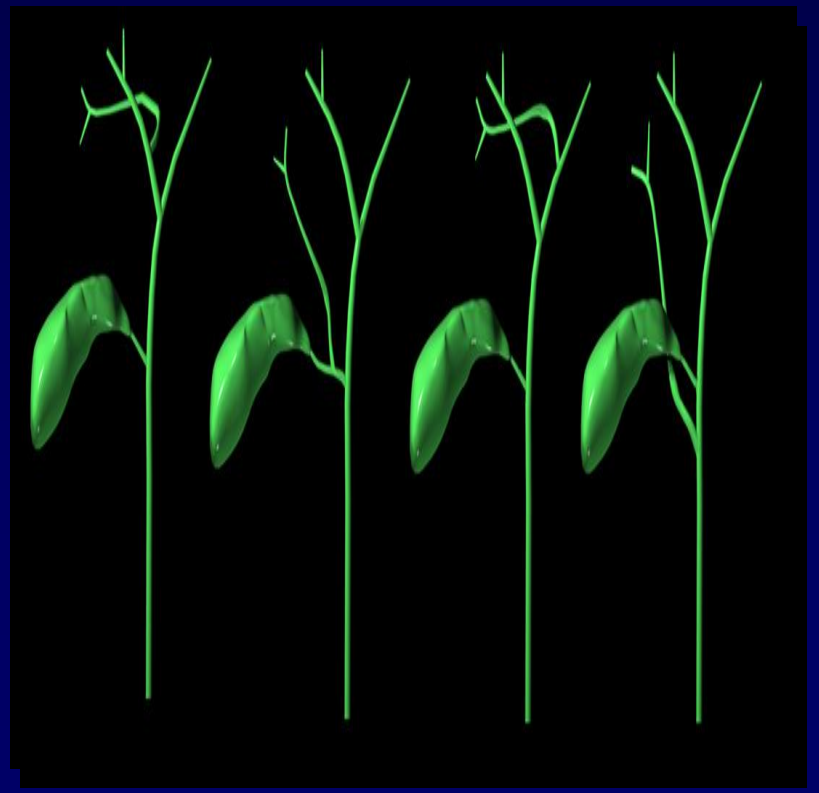
- 34 - 49% of surgeons have caused 1 or 2 major bile duct injury

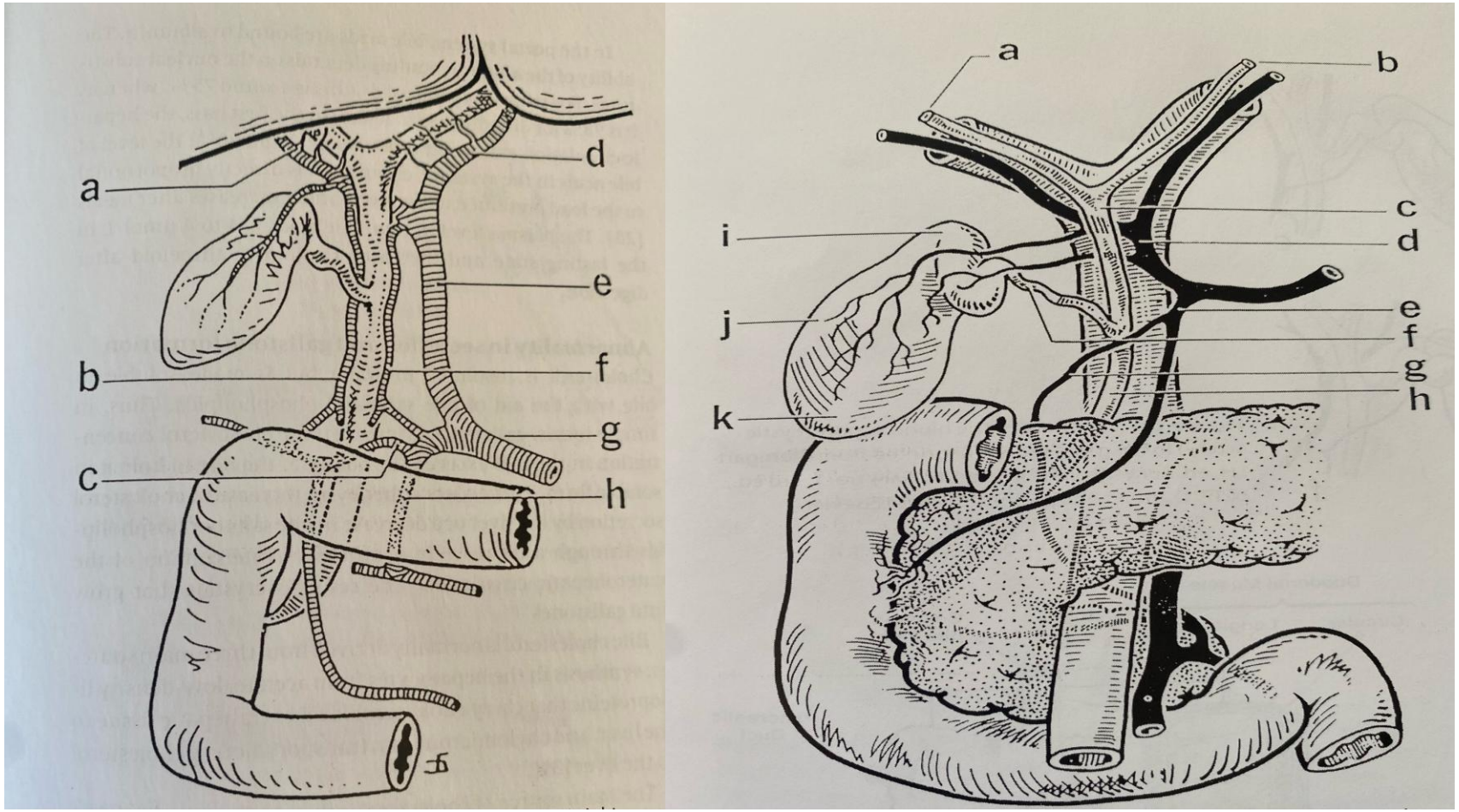
  Archer SB, Ann Surg 2001

  Fancoeur JR, Am J Surg 2003

Risk Factors
Anatomic Variations

- Present in 18-39% of cases
- Dangerous variations predisposing to BTI are present in only 3-6% of cases
  - Abnormal biliary anatomy
    - **Short cystic duct, cystic duct entering in the right hepatic duct - Accessory right hepatic duct**
  - Arterial anomalies
    - **Right hepatic artery running parallel to the cystic duct - Anomalous or accessory right hepatic artery**




a
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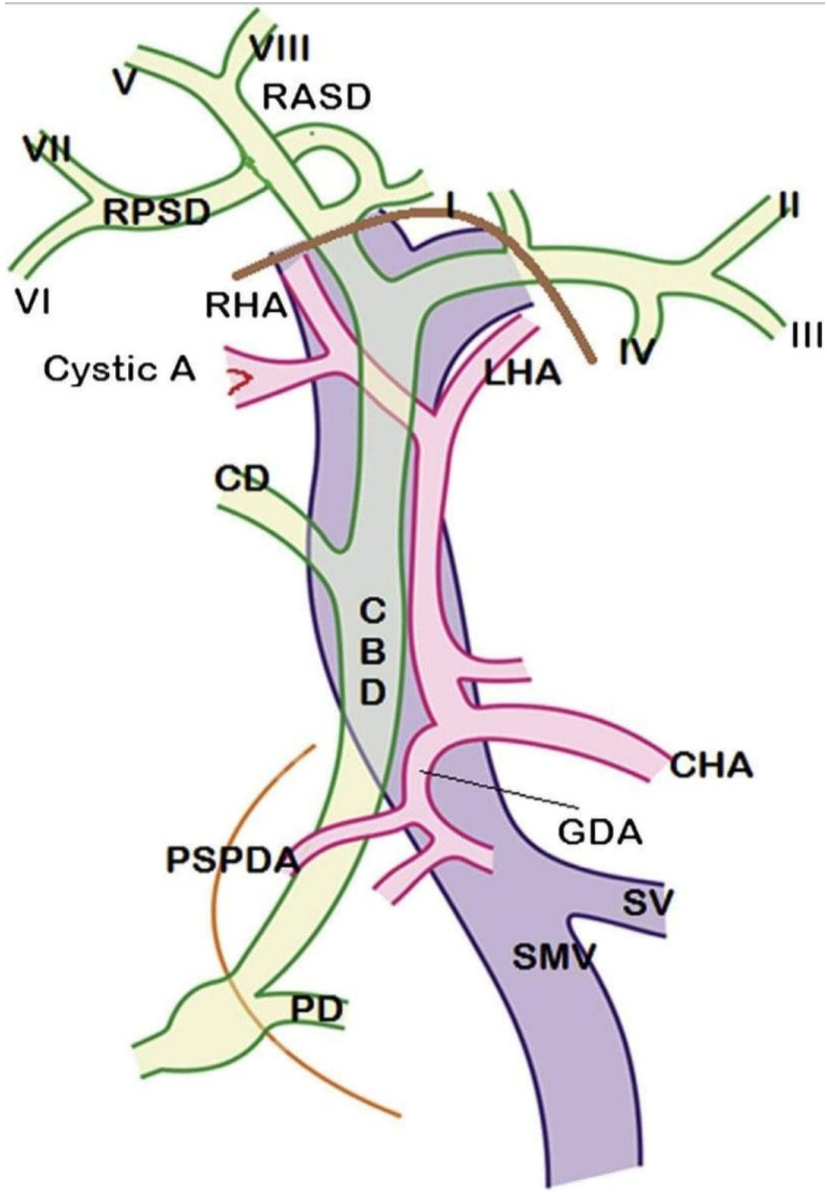
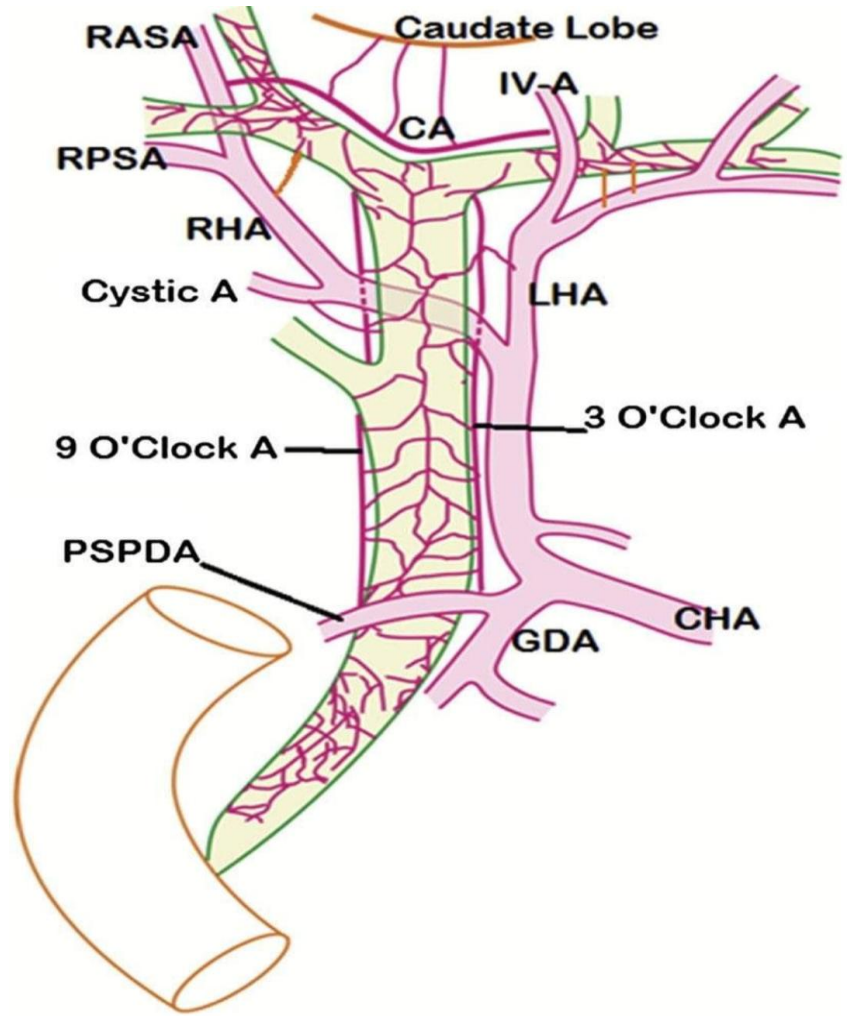
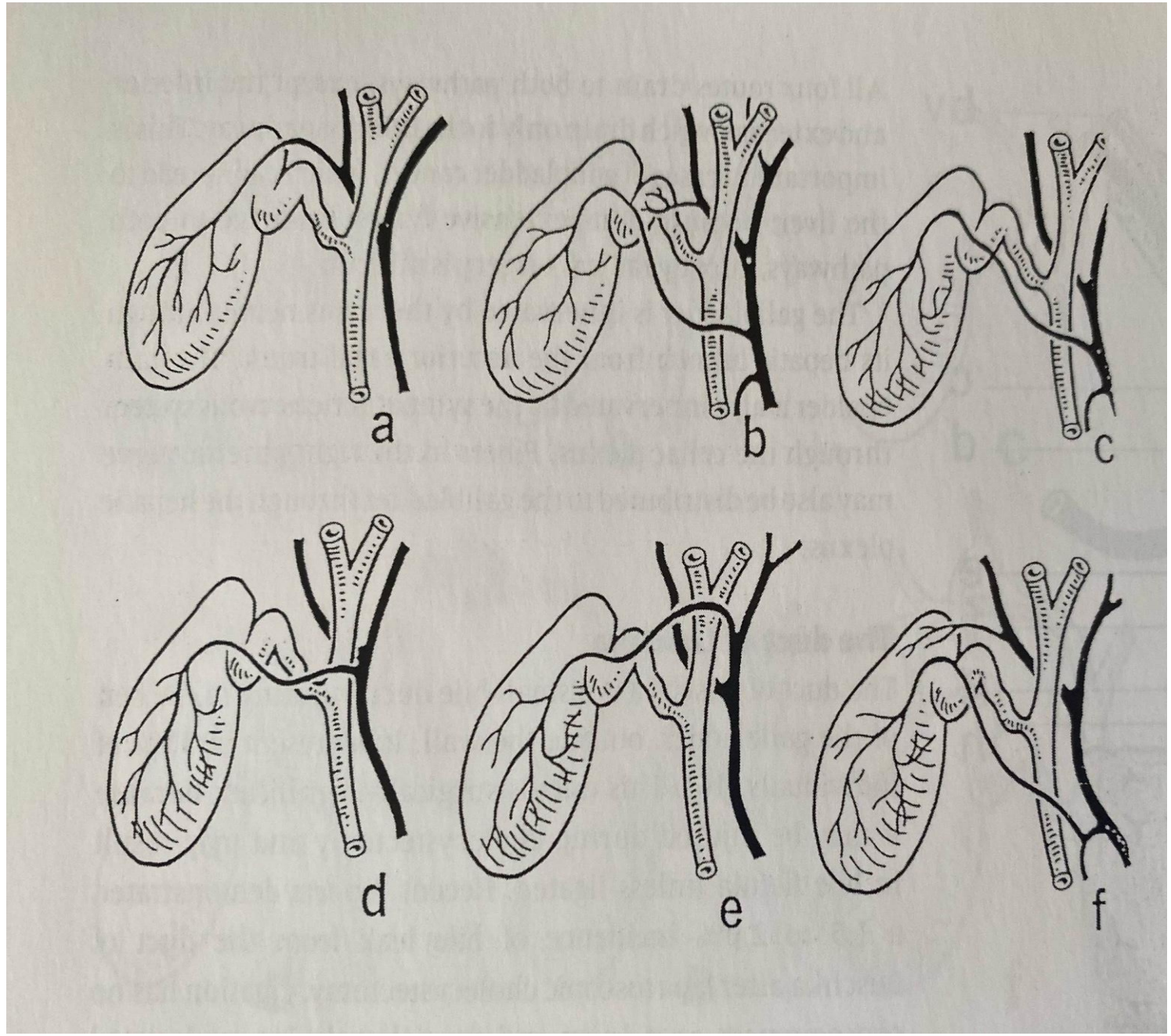
i
j
k


VIII
V
RASD
VII
RPSD
VI
I
II
III
IV
RHA
Cystic A
LHA
CD
C
B
D
CHA
GDA
PSPDA
SV
SMV
PD


RASA
Caudate Lobe
IV-A
CA
RPSA
RHA
Cystic A
LHA
3 O'Clock A
9 O'Clock A
PSPDA
CHA
GDA


a
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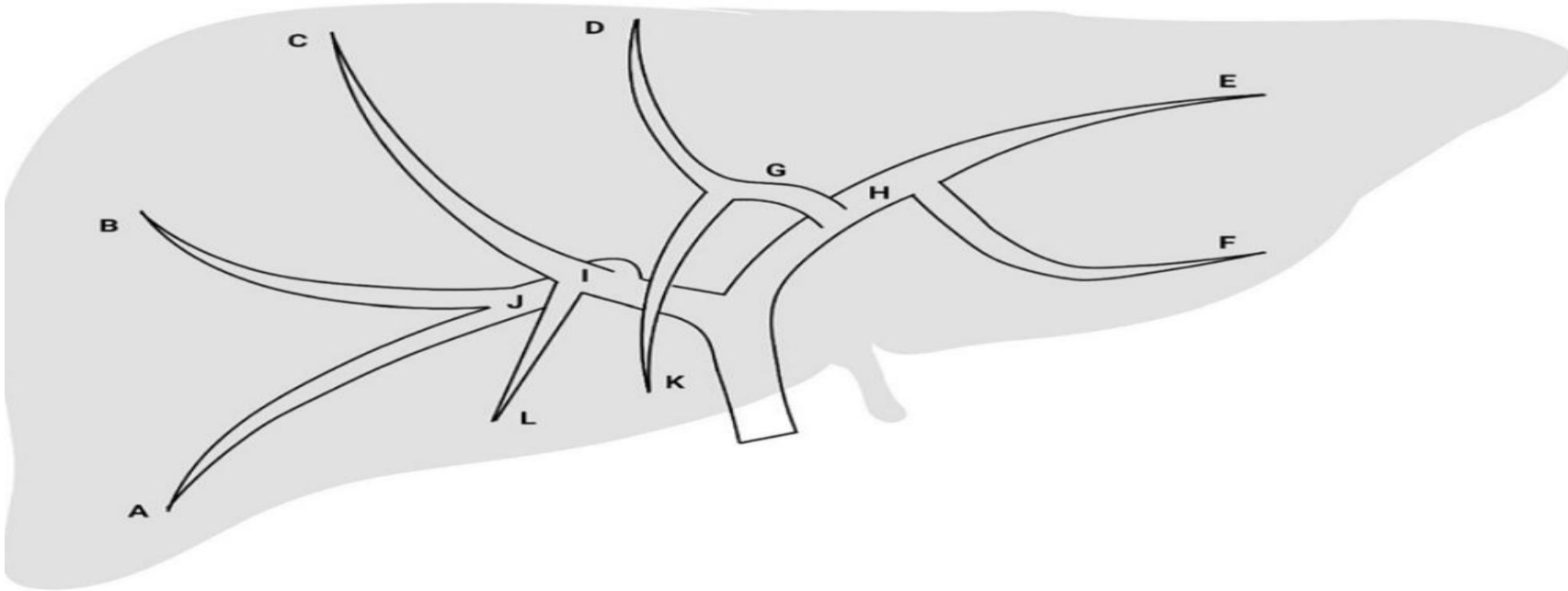
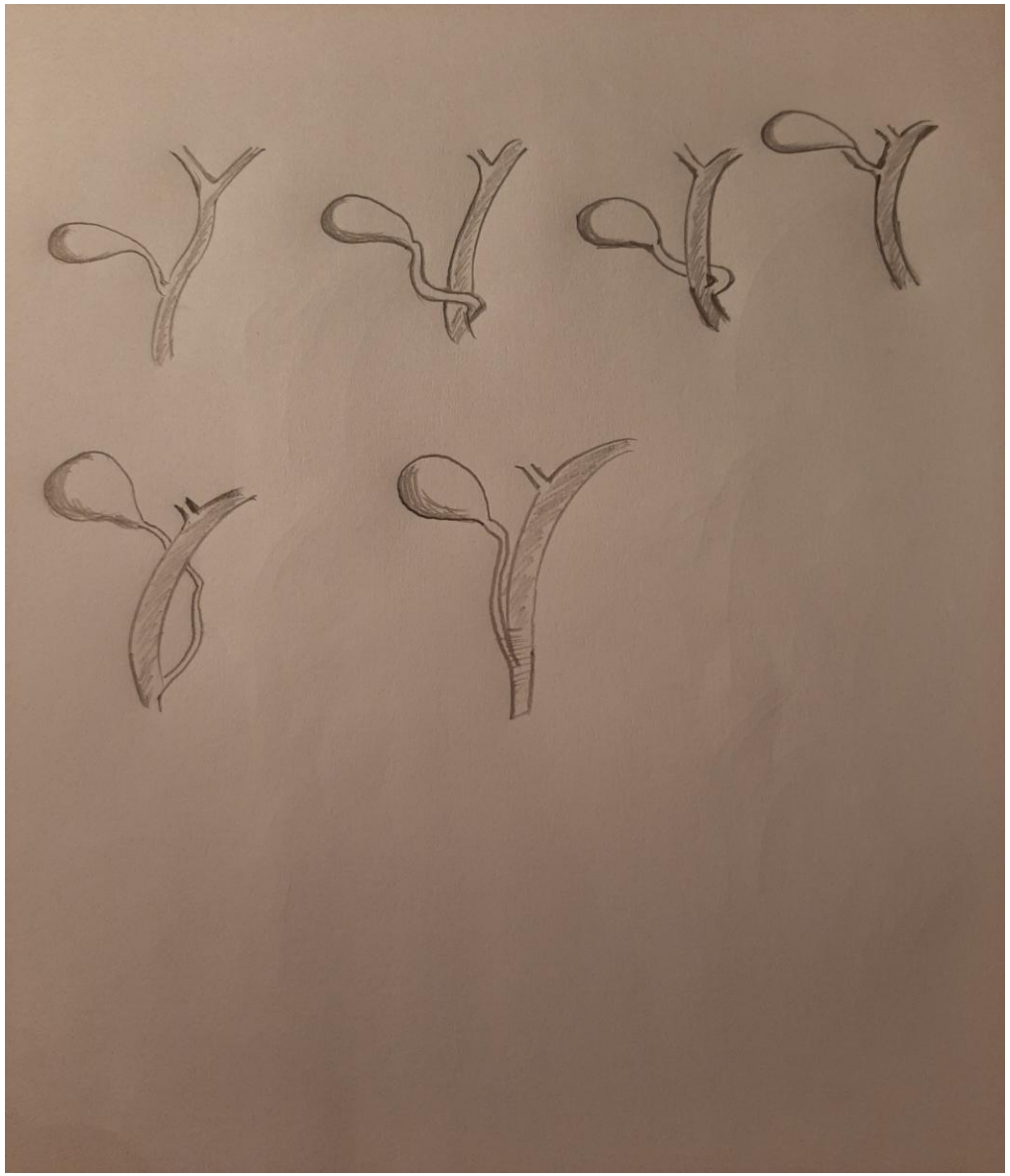
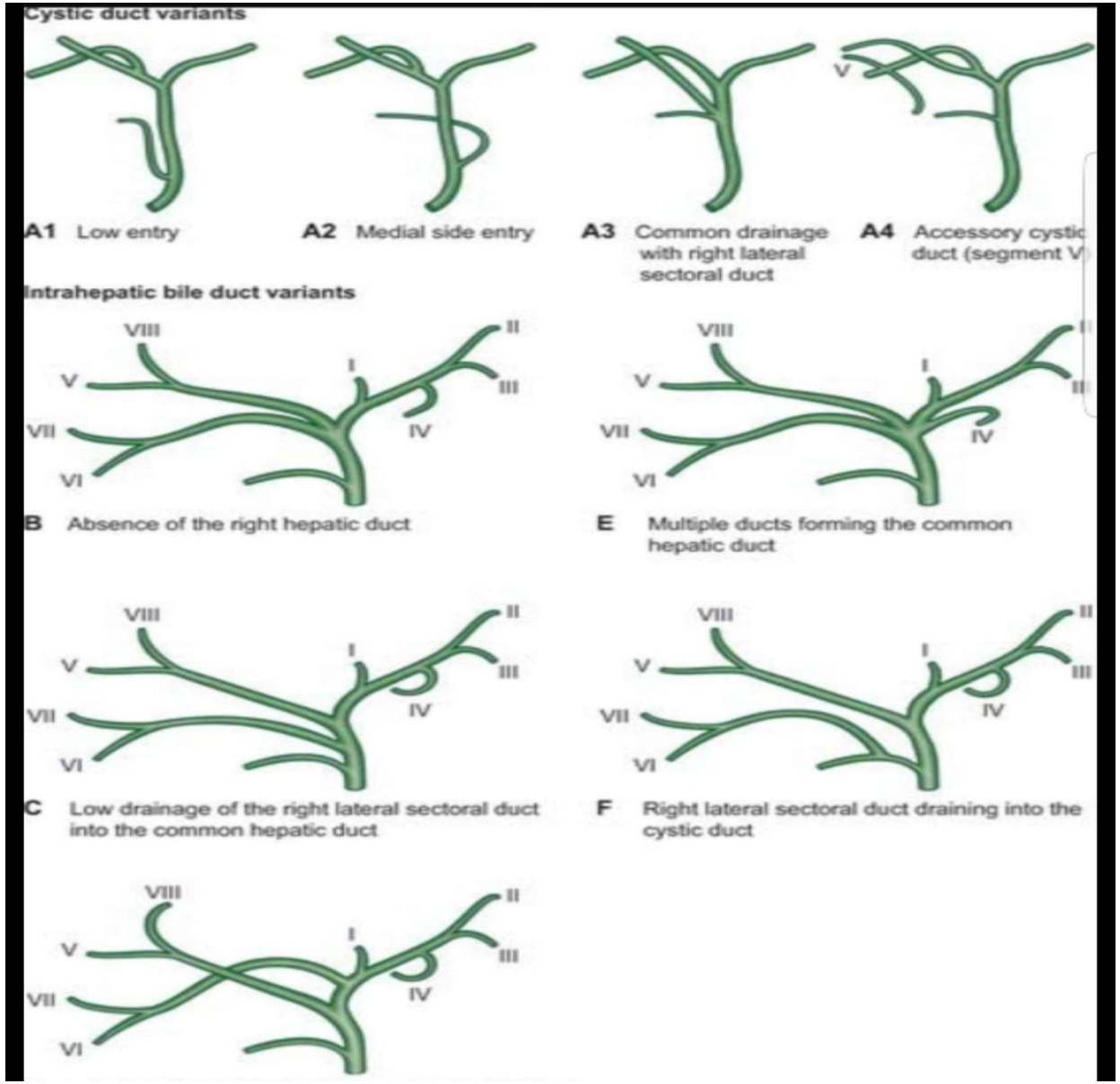
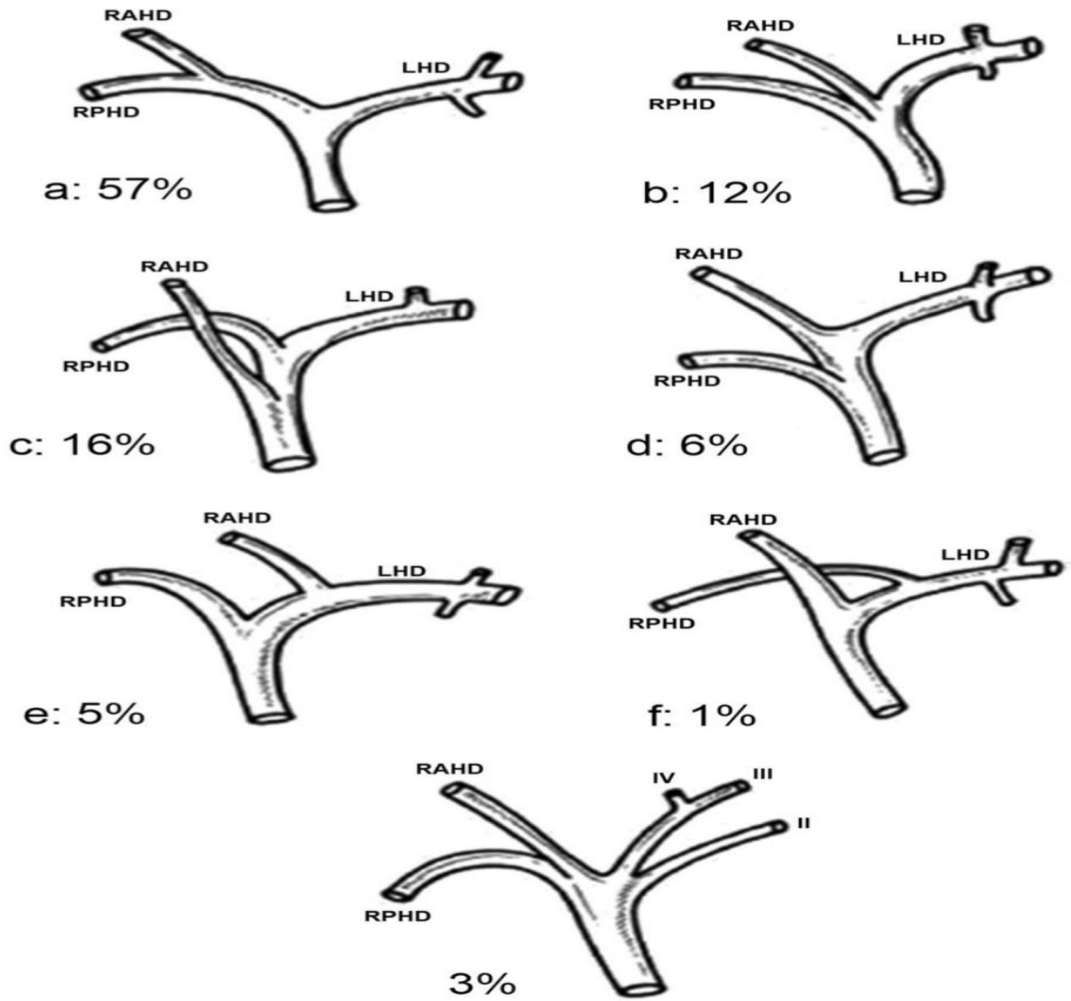


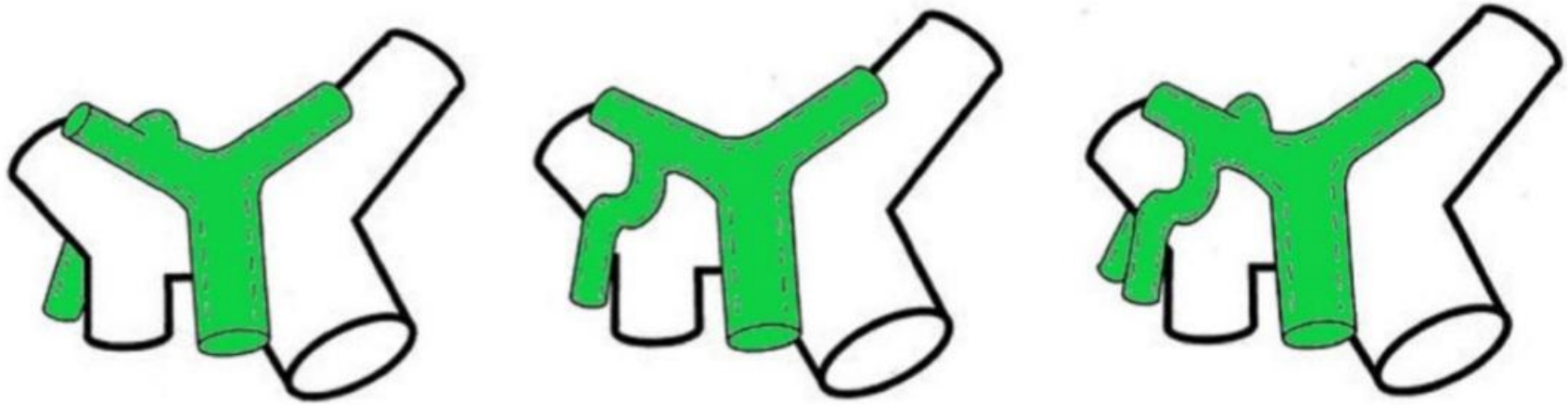
- Left lateral sectoral: **H**
- Left medial sectoral: **G**
- Segment V: **L**
- Segment VI: **A**
- Segment VII: **B**
- Segment IVa: **D**
- Segment II: **E**



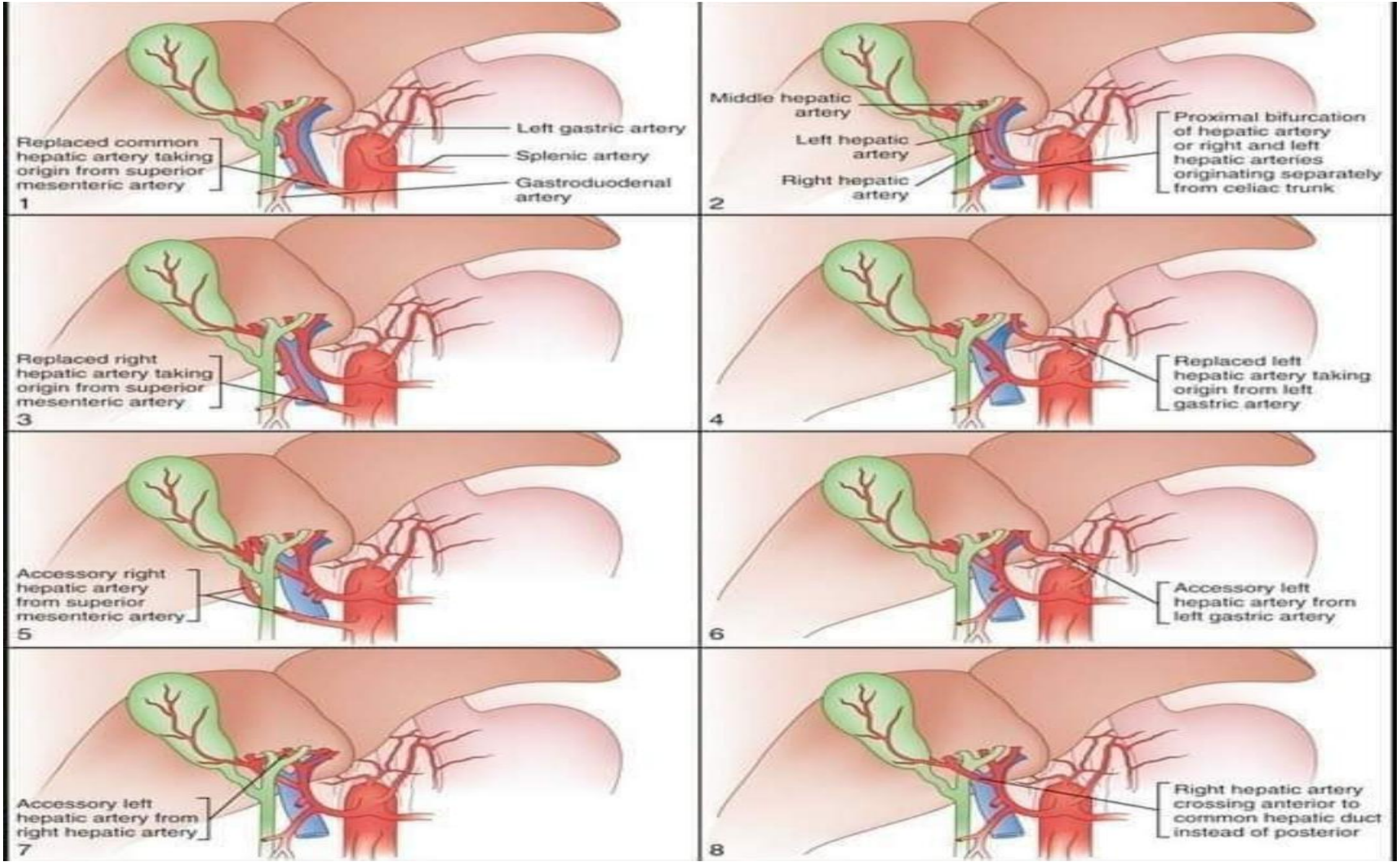

Cystic duct variants
A1 Low entry
A2 Medial side entry
A3 Common drainage with right lateral sectoral duct
A4 Accessory cystic duct (segment V)
Intrahepatic bile duct variants
B Absence of the right hepatic duct
E Multiple ducts forming the common hepatic duct
C Low drainage of the right lateral sectoral duct into the common hepatic duct
F Right lateral sectoral duct draining into the cystic duct
VIII
V
VII
VI
I
II
III
IV

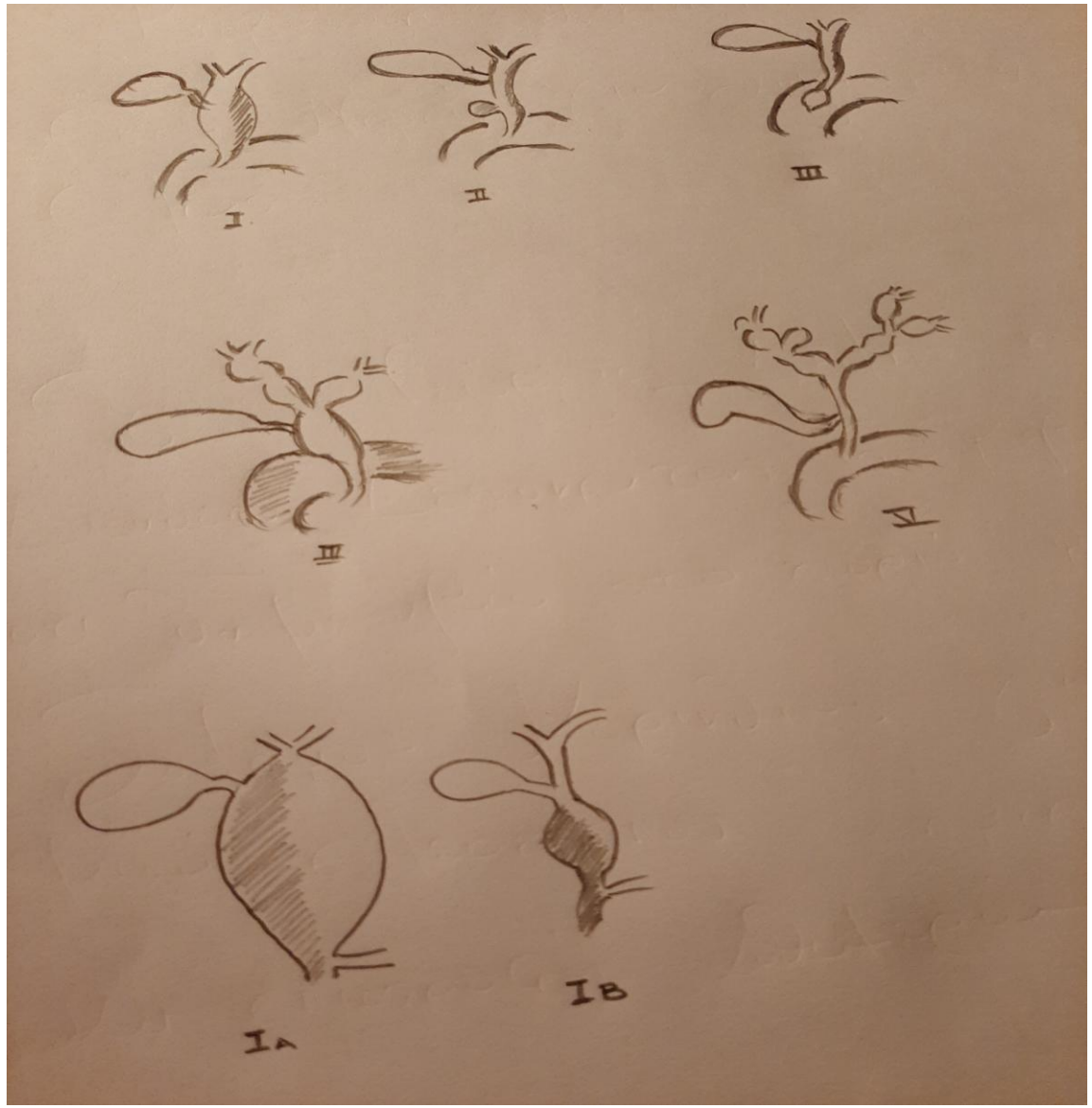


LHD: left hepatic duct, RAHD: right anterior hepatic duct, RPHD: right posterior hepatic duct



a b c


Replaced common hepatic artery taking origin from superior mesenteric artery
Left gastric artery
Splenic artery
Gastroduodenal artery
1
Middle hepatic artery
Left hepatic artery
Right hepatic artery
Proximal bifurcation of hepatic artery or right and left hepatic arteries originating separately from celiac trunk
2
Replaced right hepatic artery taking origin from superior mesenteric artery
3
Replaced left hepatic artery taking origin from left gastric artery
4
Accessory right hepatic artery from superior mesenteric artery
5
Accessory left hepatic artery from left gastric artery
6
Accessory left hepatic artery from right hepatic artery
7
Right hepatic artery crossing anterior to common hepatic duct instead of posterior
8

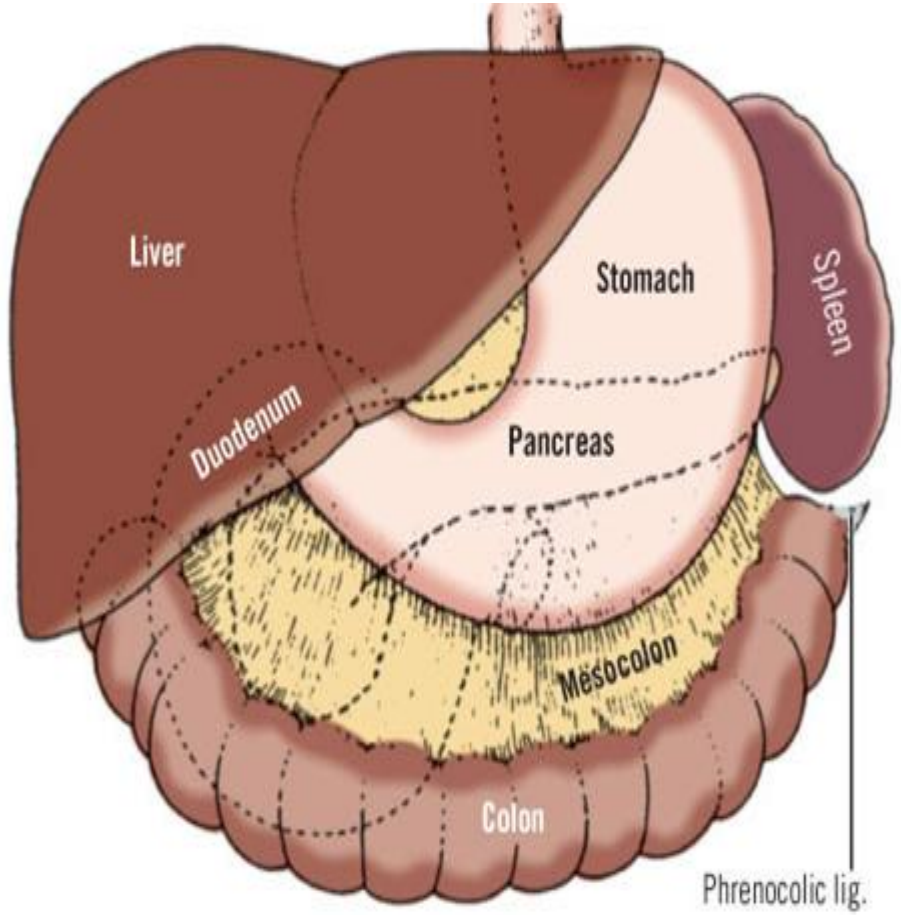

I
II
III
III
IV
IA
IB

Anatomic relations

(anterior)

- (stomach)

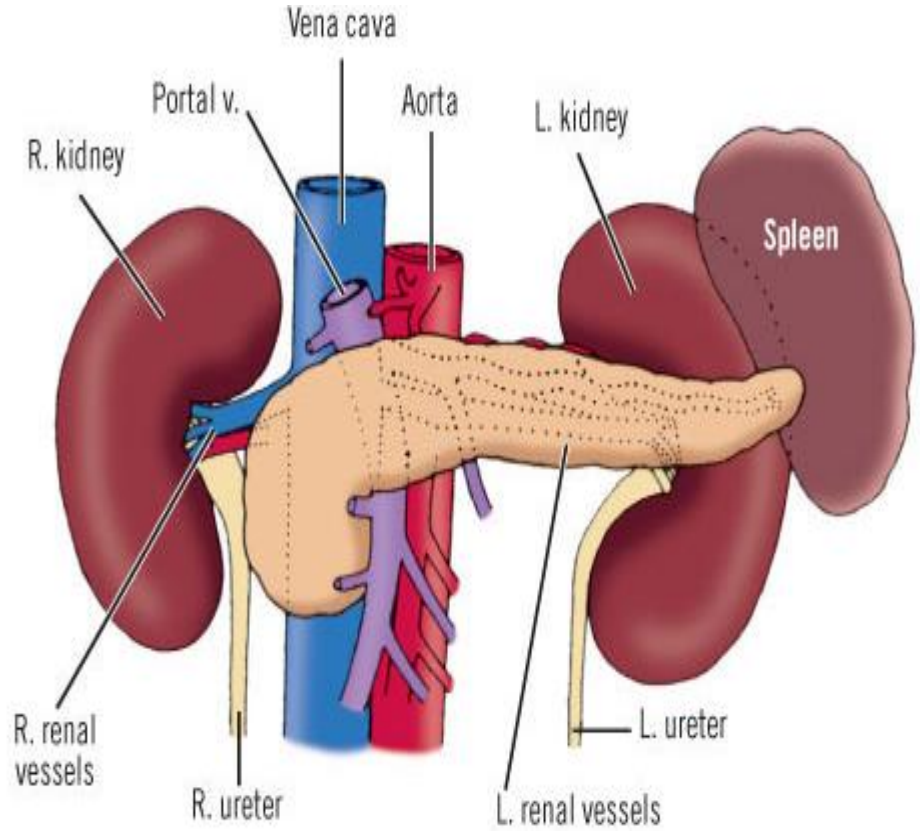
(transverse colon)



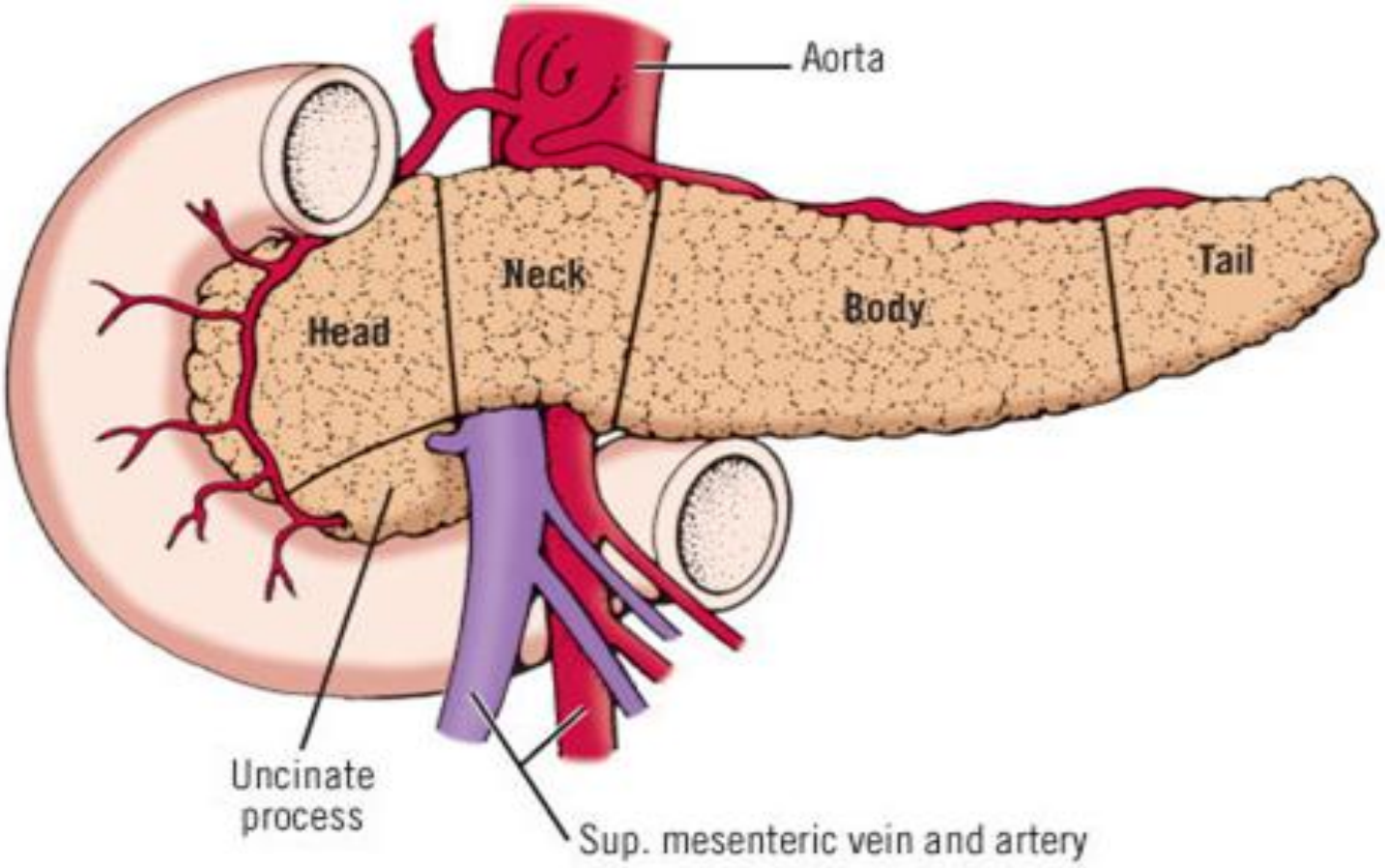
Anatomic relations

(posterior)

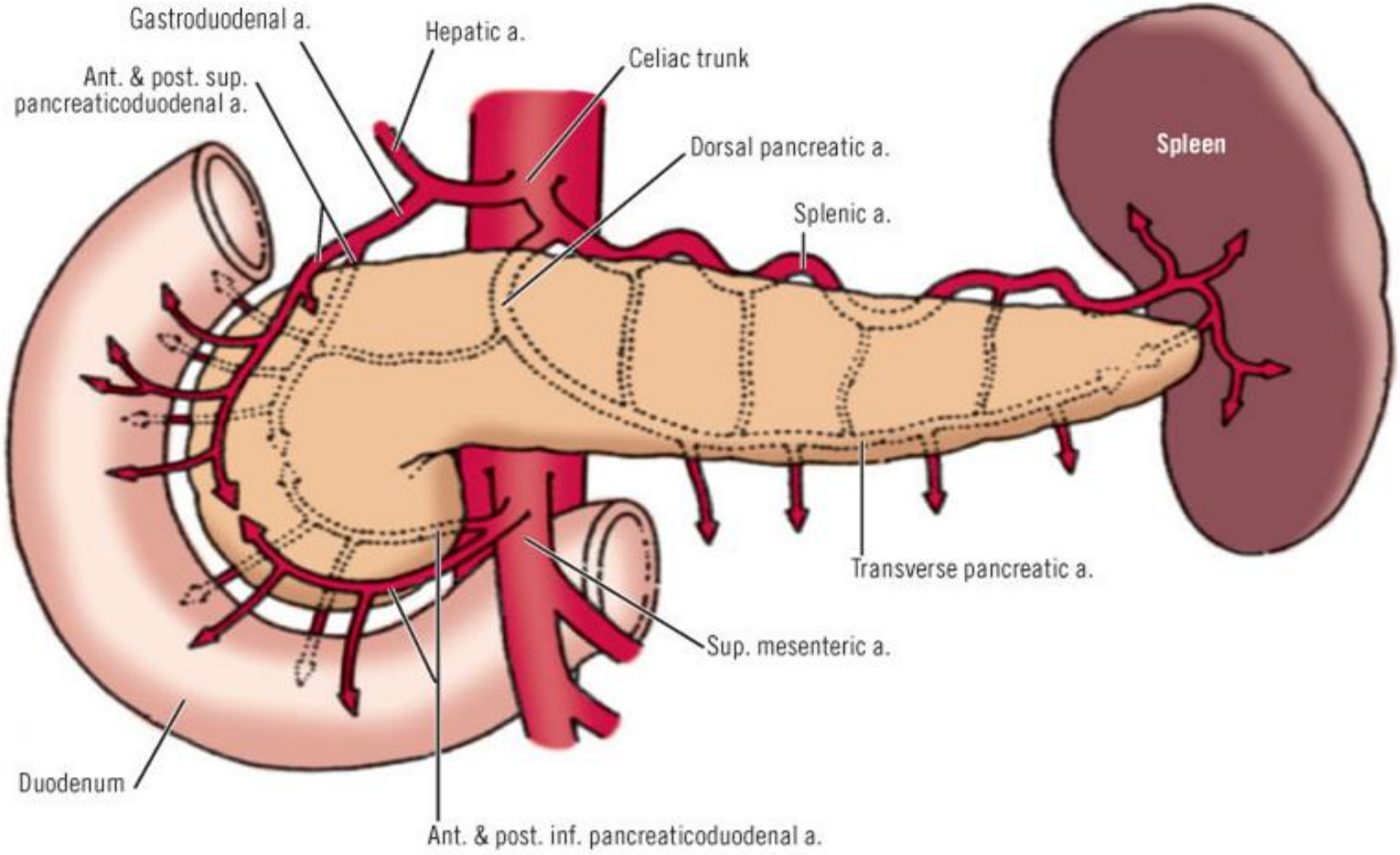
- (IVC)
- (Aorta)
- (SMA) (Splenic)
- Kidney, adrenal gland
- (Diaphragm)



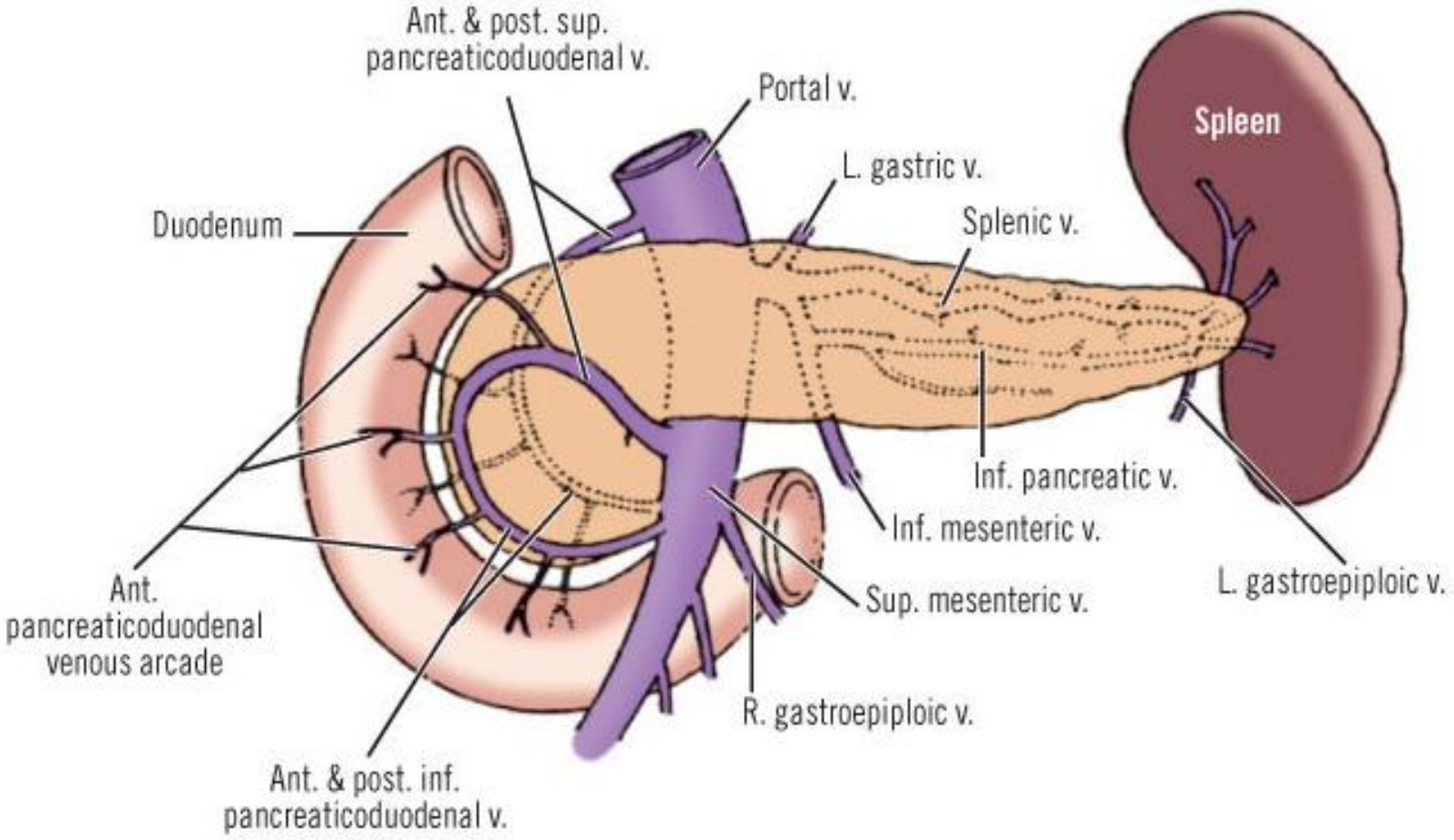
(Pancreatic segments)



Arteries


Gastroduodenal a.
Hepatic a.
Celiac trunk
Ant. & post. sup. pancreaticoduodenal a.
Dorsal pancreatic a.
Spleen
Splenic a.
Transverse pancreatic a.
Sup. mesenteric a.
Duodenum
Ant. & post. inf. pancreaticoduodenal a.

Veins


Ant. & post. sup.
pancreaticoduodenal v.
Portal v.
L. gastric v.
Splenic v.
Spleen
Duodenum
Inf. pancreatic v.
Inf. mesenteric v.
Sup. mesenteric v.
L. gastroepiploic v.
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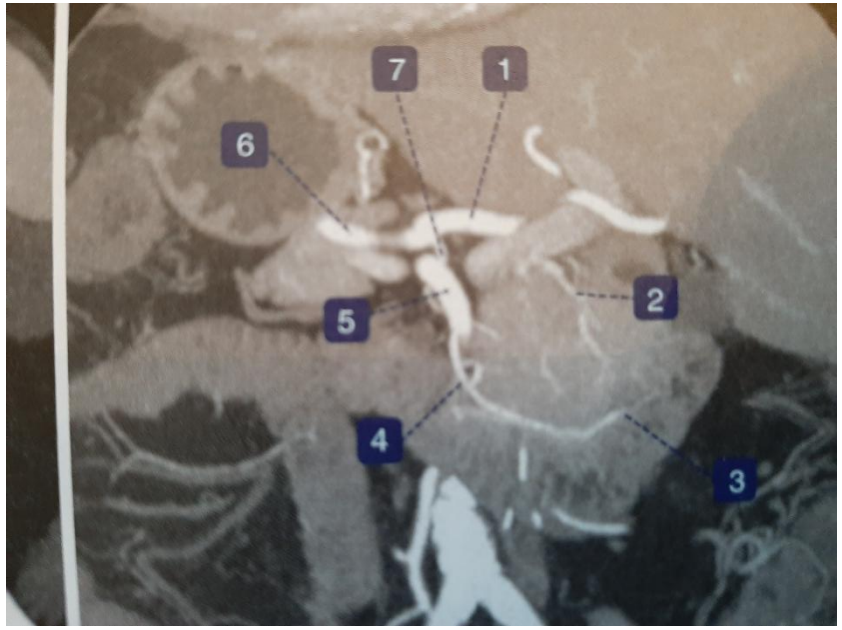
pancreaticoduodenal
venous arcade
R. gastroepiploic v.
Ant. & post. inf.
pancreaticoduodenal v.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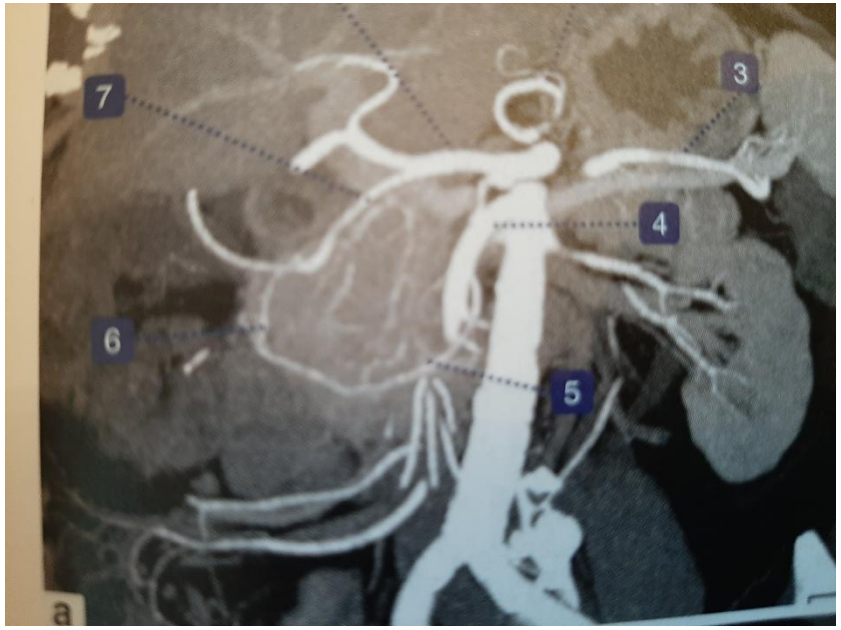
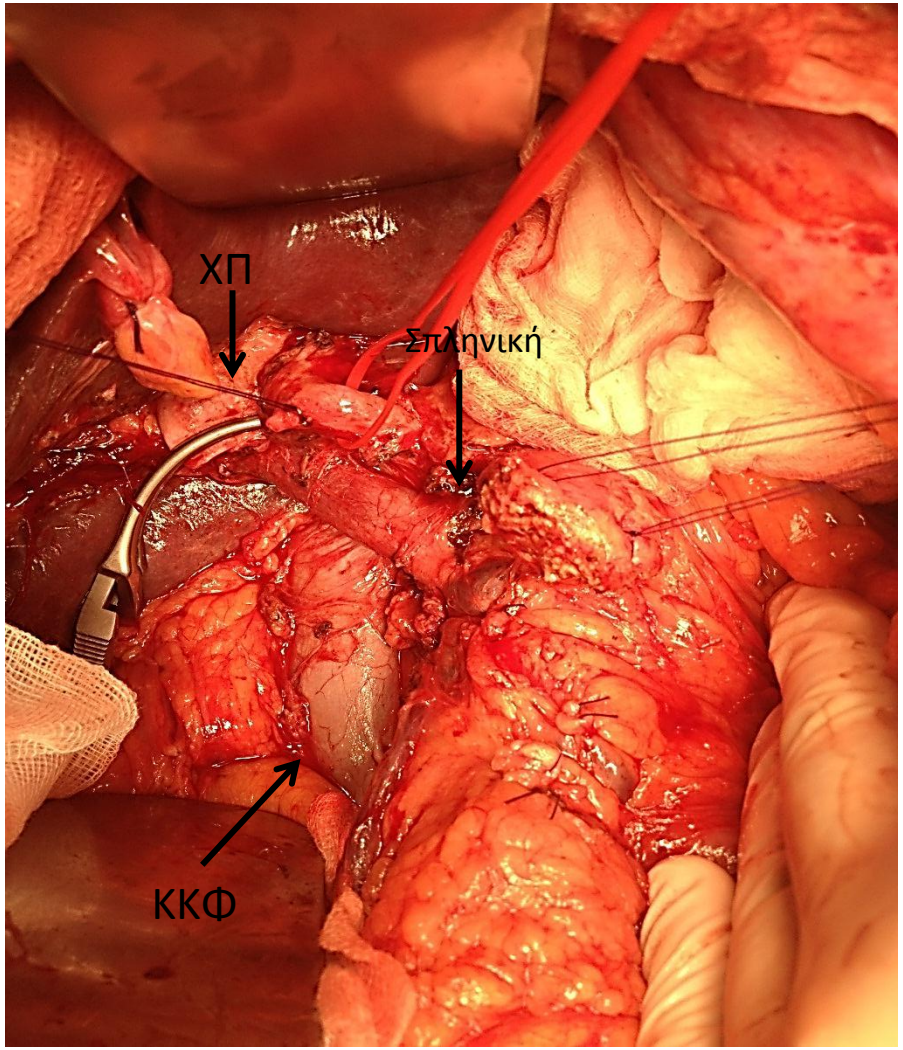
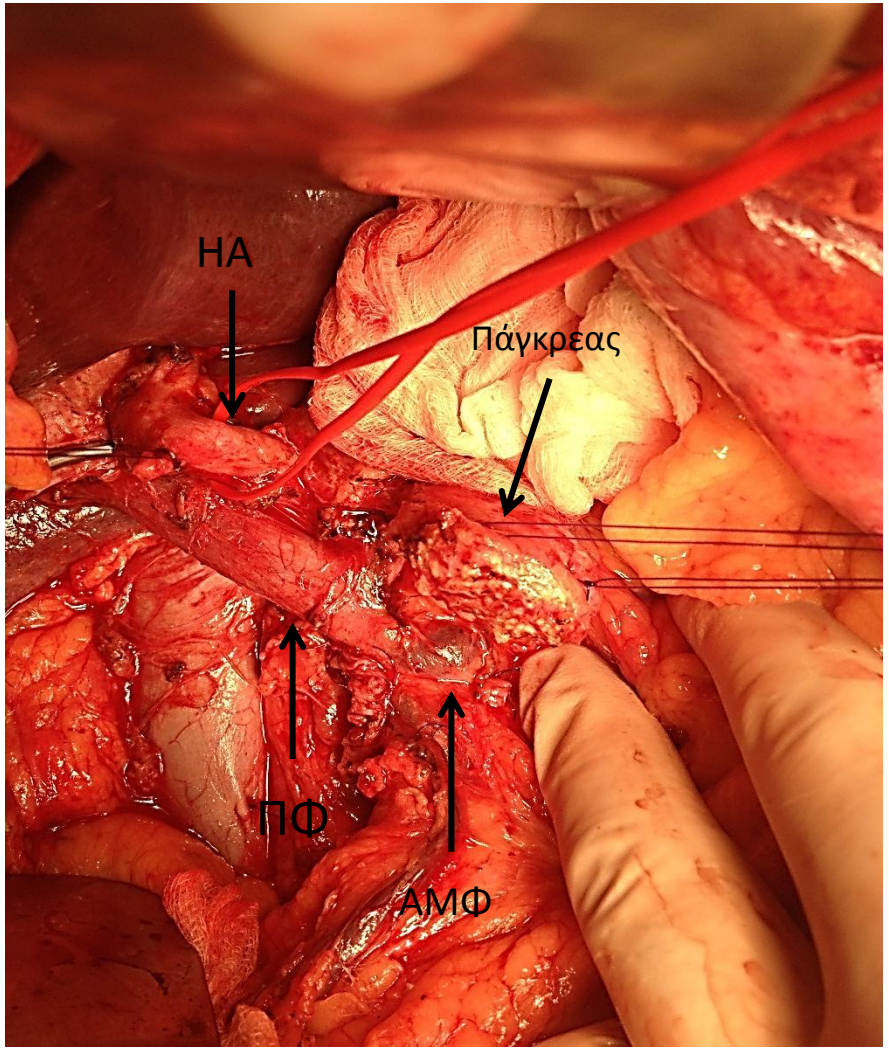
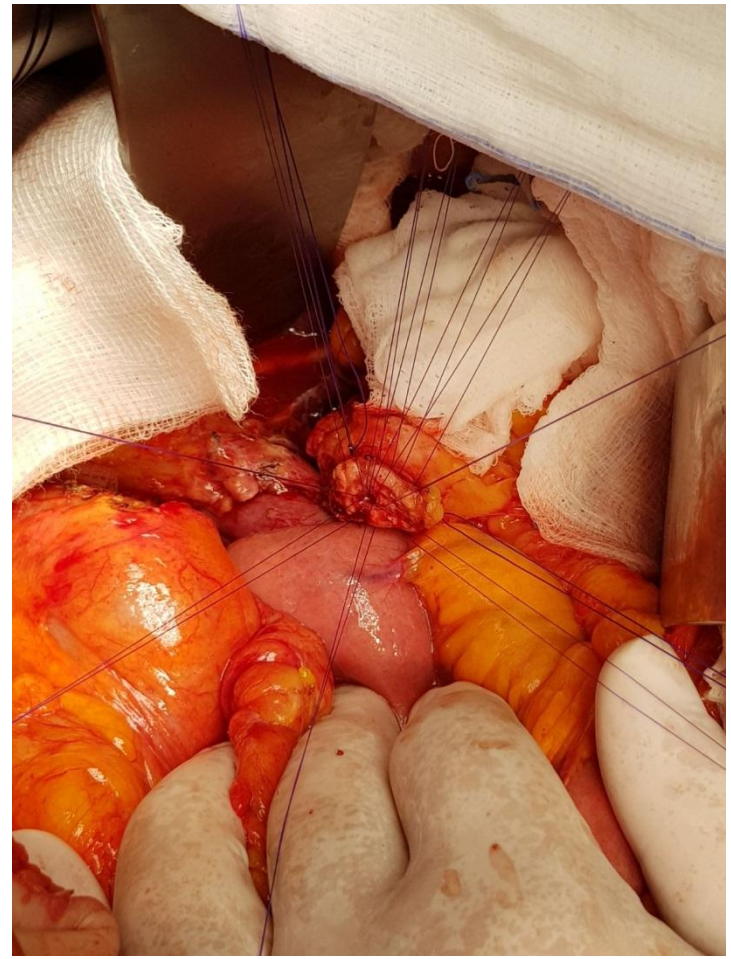
4
3

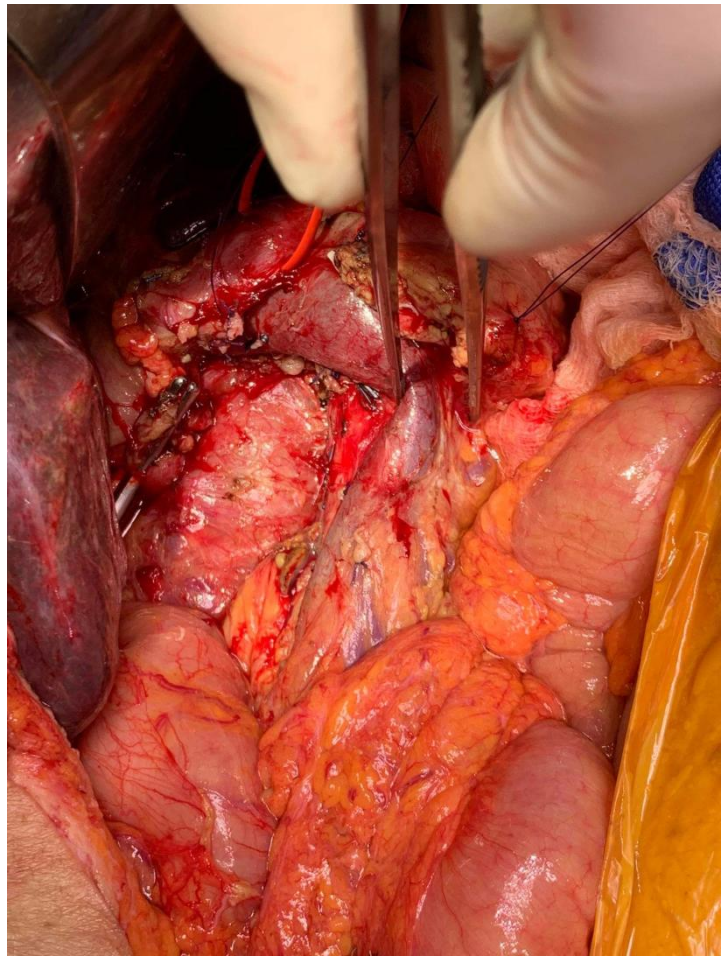

7
3
4
6
5
a

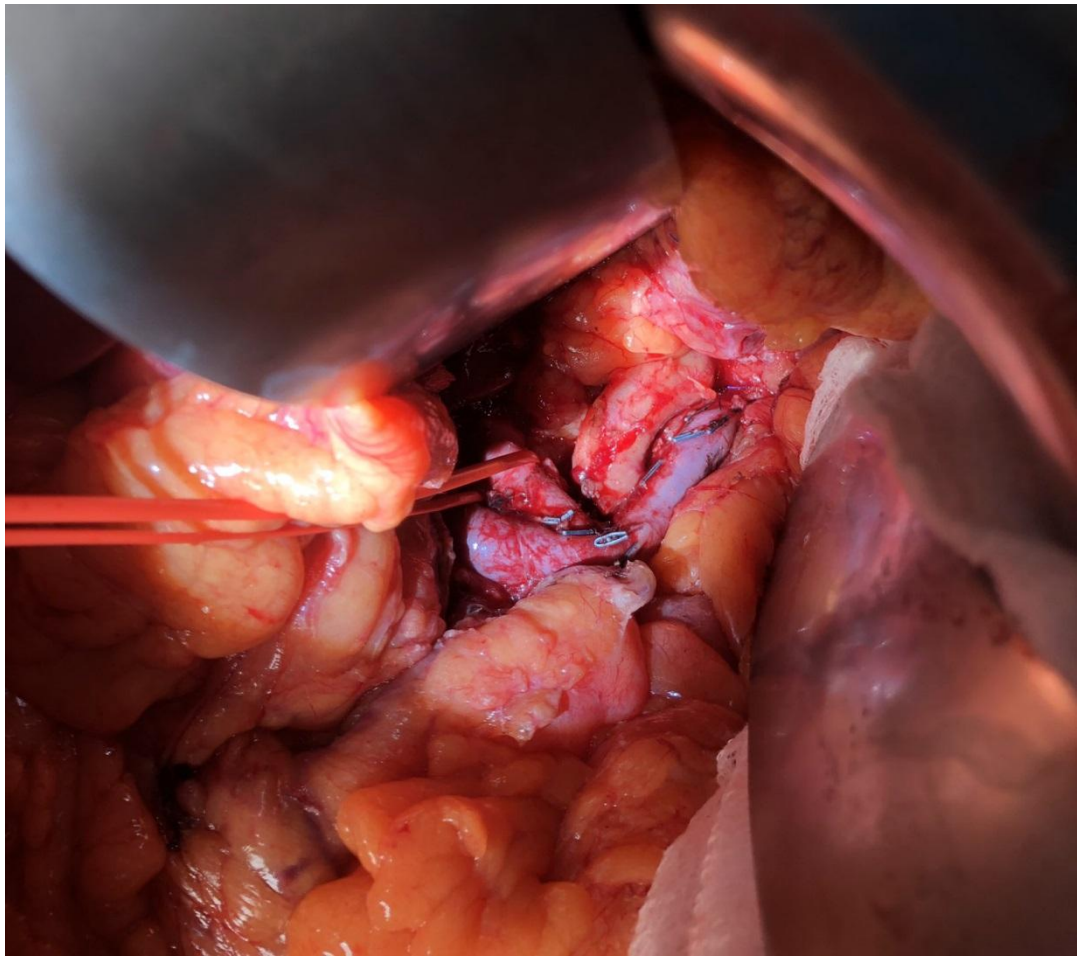
PORTAL VEIN

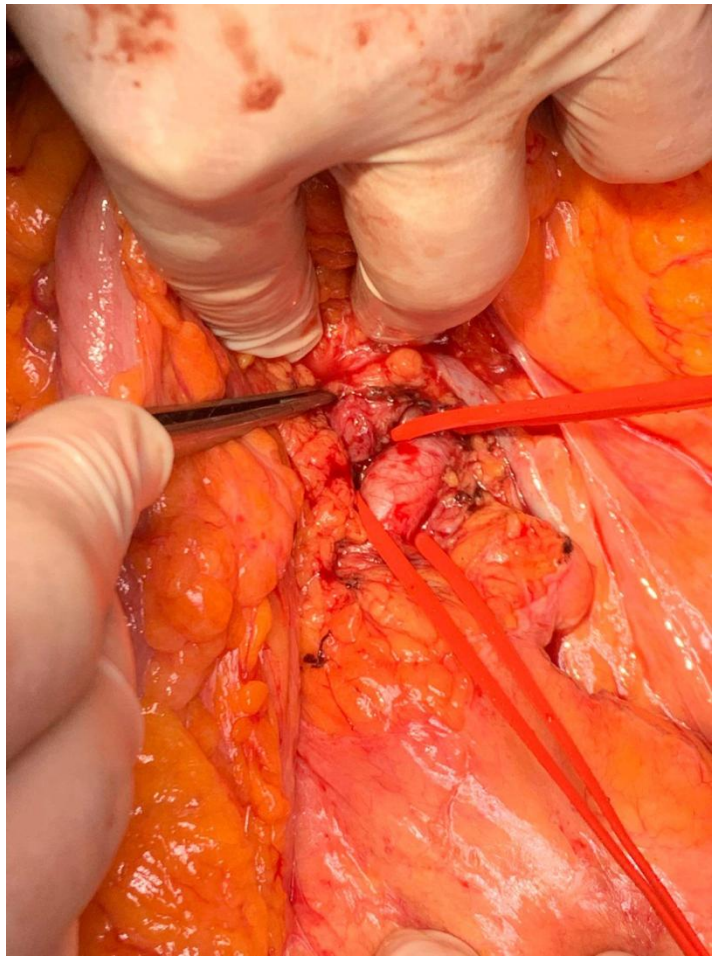


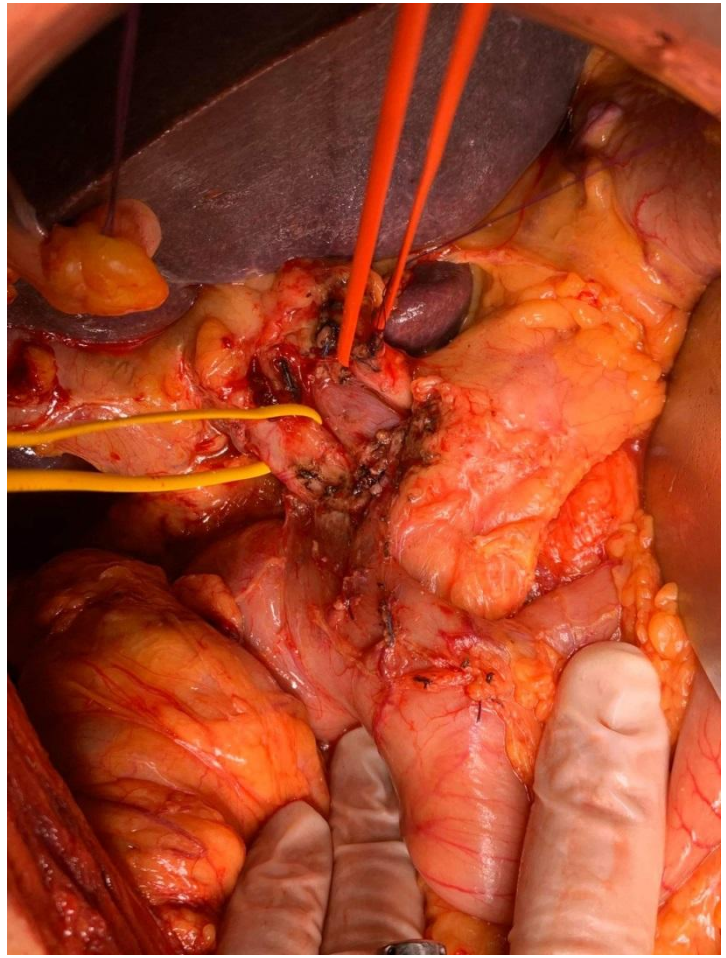


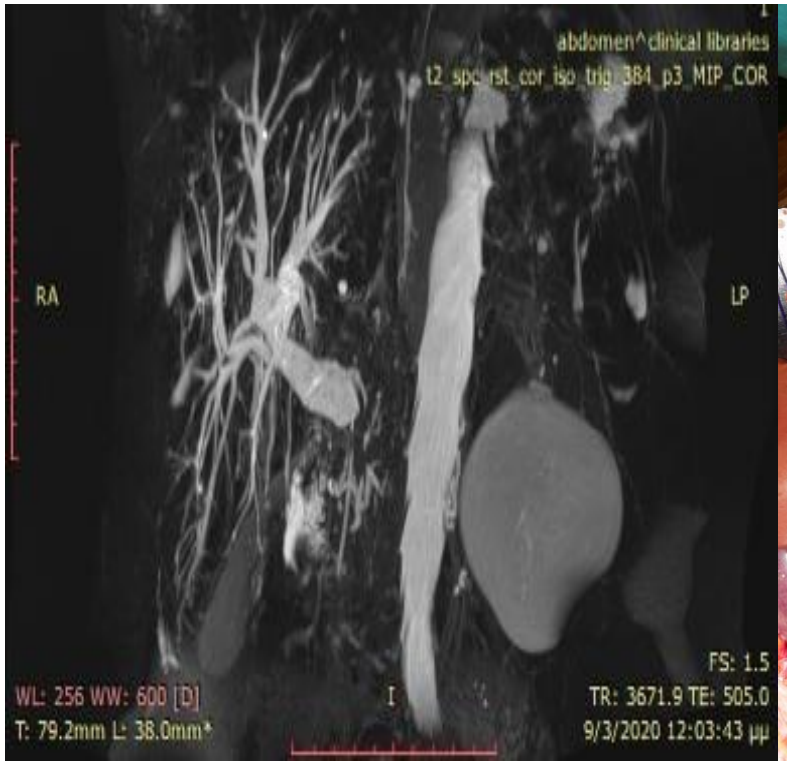


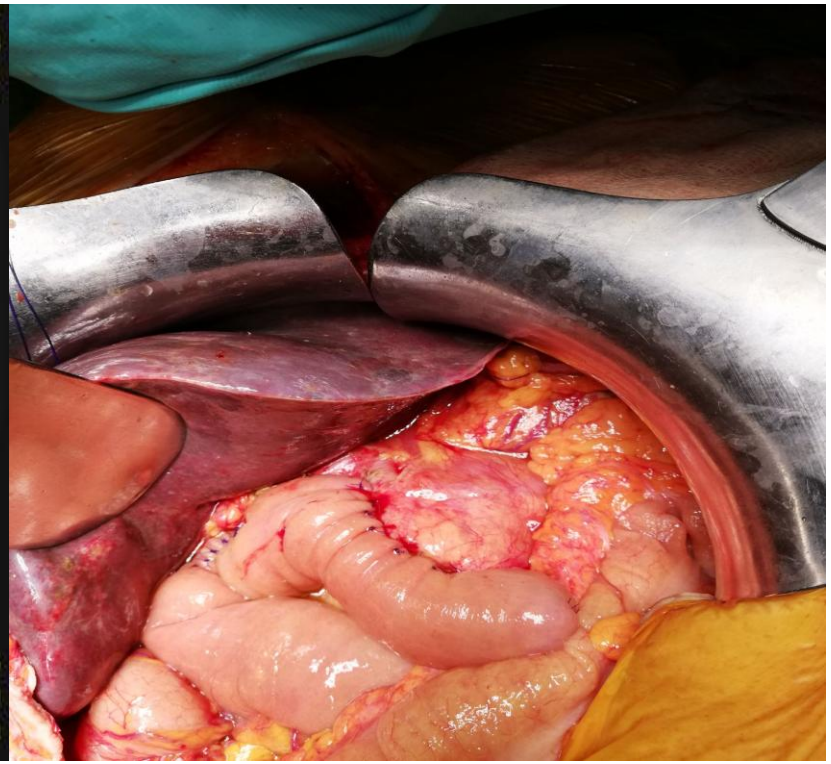


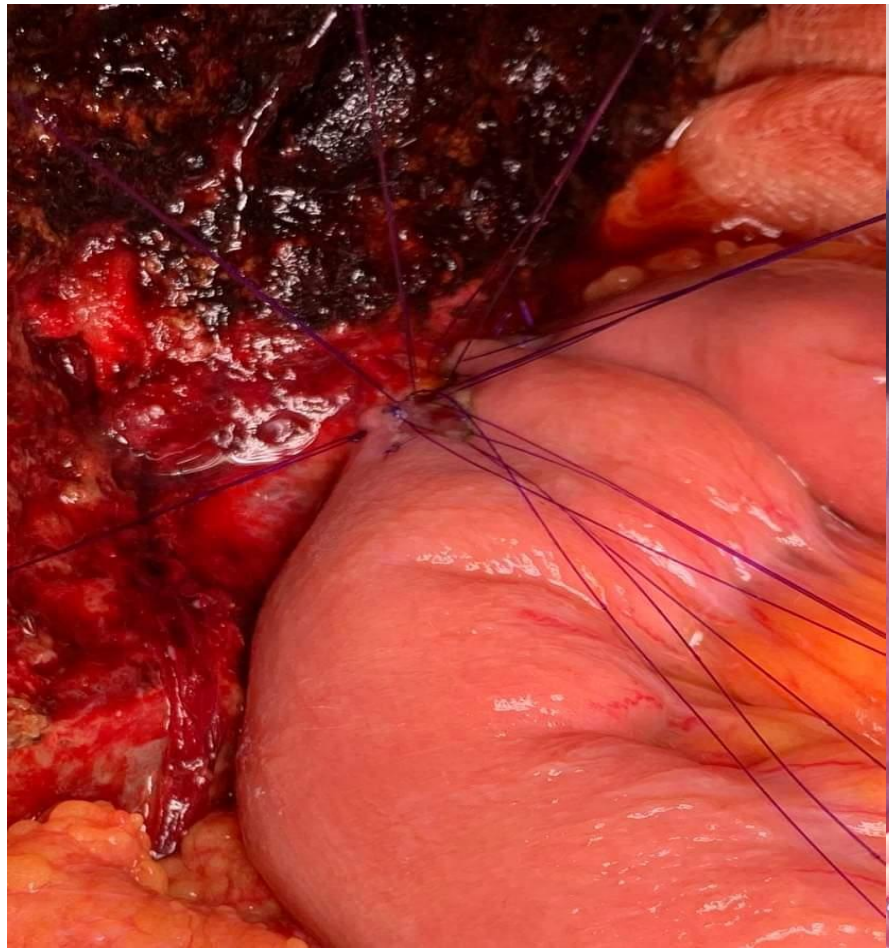


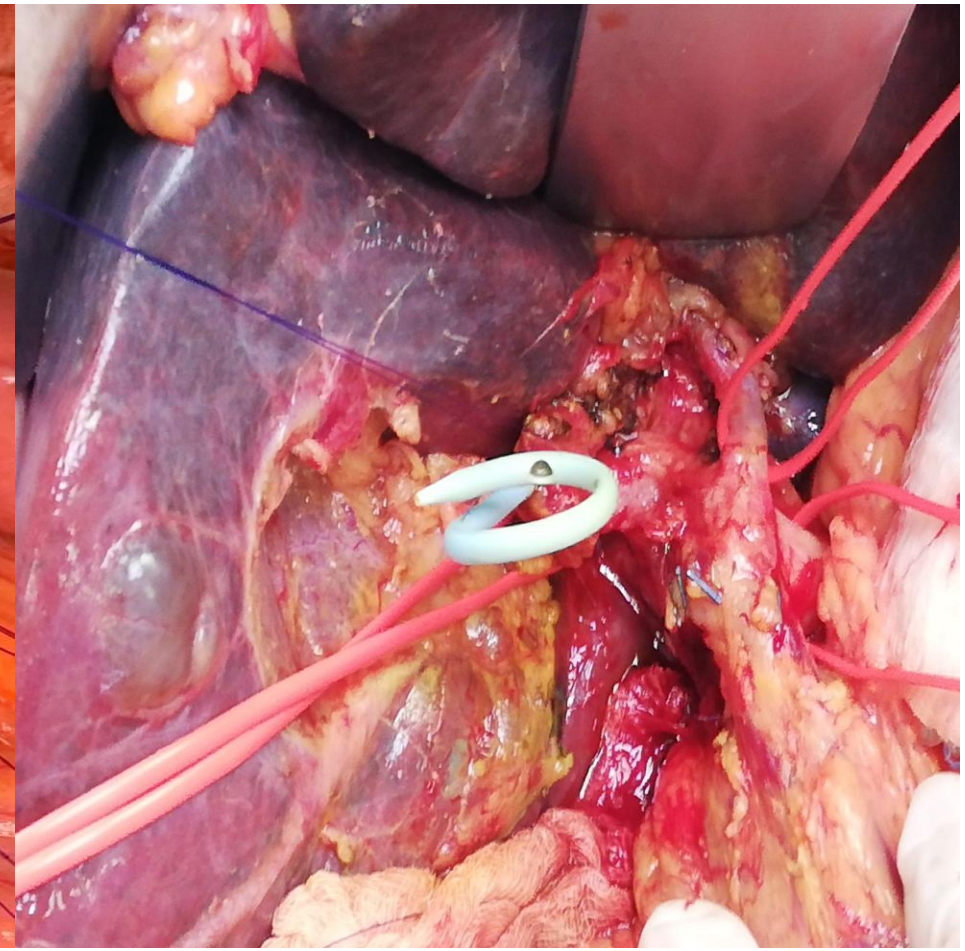


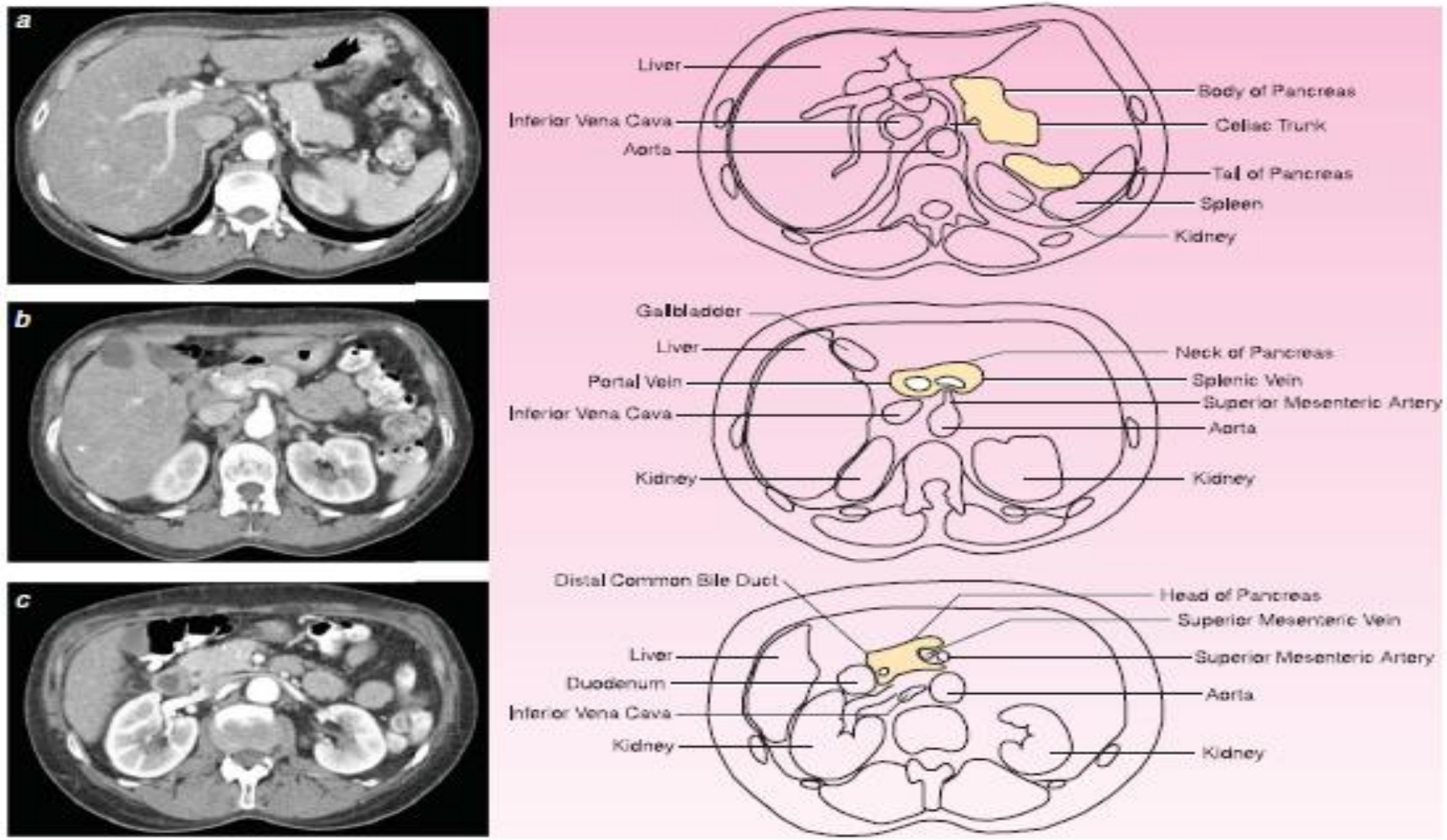



abdomen^clinical libraries
RA
LP
WL: 256 WW: 600 [D]
T: 79.2mm L: 38.0mm*
FS: 1.5
TR: 3671.9 TE: 505.0
9/3/2020 12:03:43 μμ



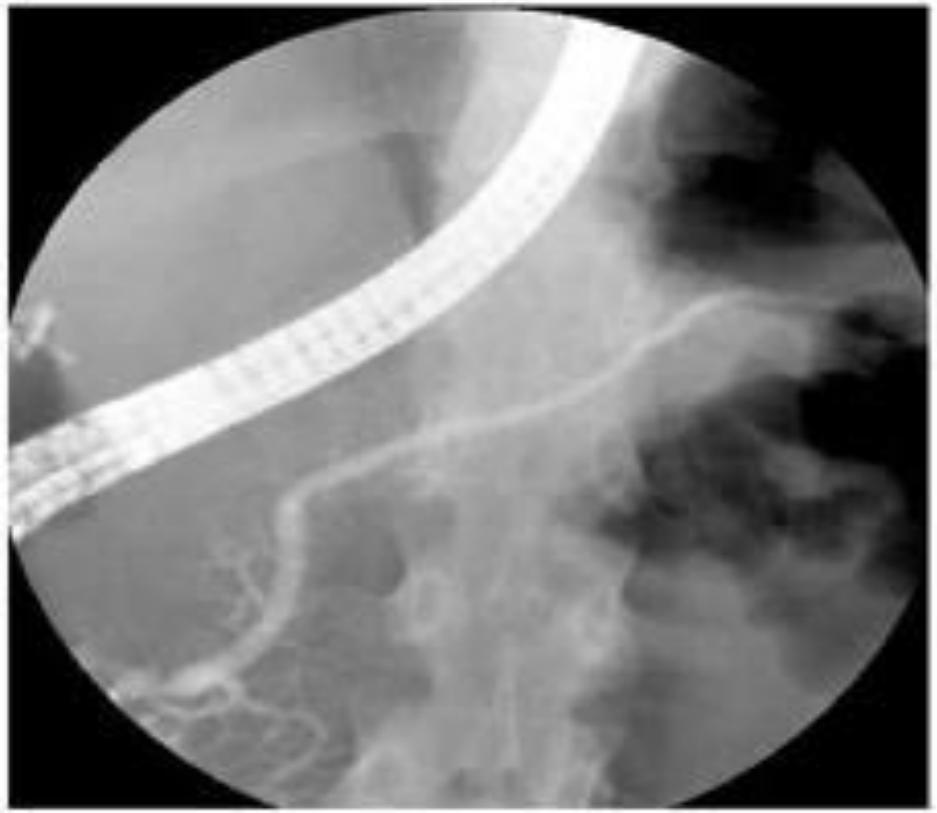





a
b
c
Liver
Inferior Vena Cava
Aorta
Body of Pancreas
Celiac Trunk
Tail of Pancreas
Spleen
Kidney
Gallbladder
Liver
Portal Vein
Inferior Vena Cava
Kidney
Neck of Pancreas
Splenic Vein
Superior Mesenteric Artery
Aorta
Kidney
Distal Common Bile Duct
Liver
Duodenum
Inferior Vena Cava
Kidney
Head of Pancreas
Superior Mesenteric Vein
Superior Mesenteric Artery
Aorta
Kidney

(main PD)

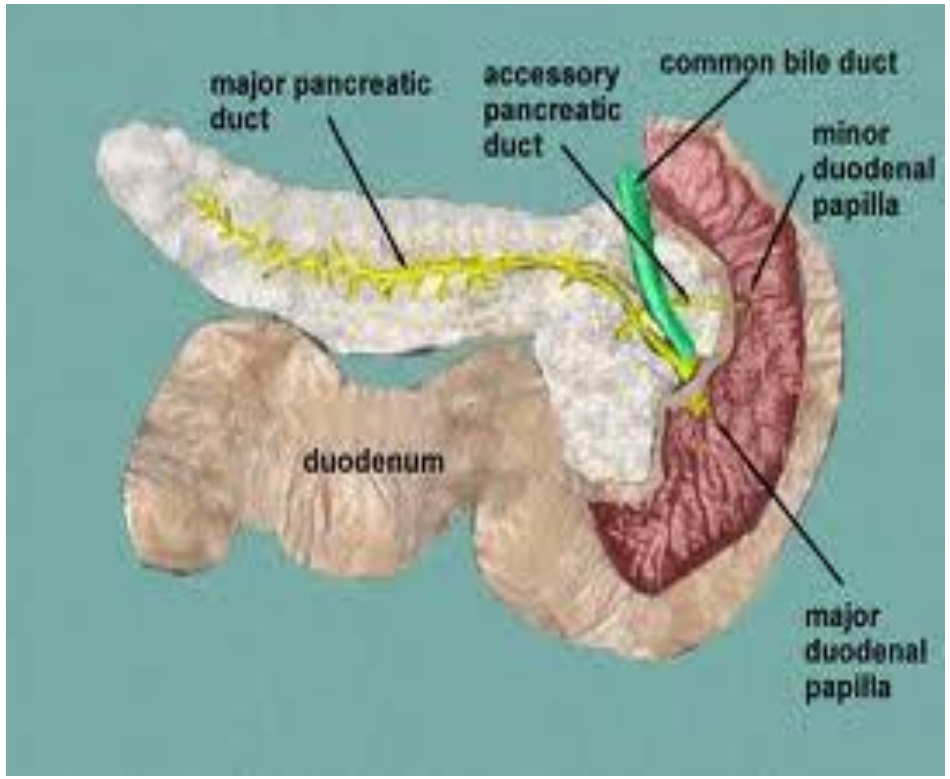
-
- 15-20 branches
- Head 3mm,tail 1mm



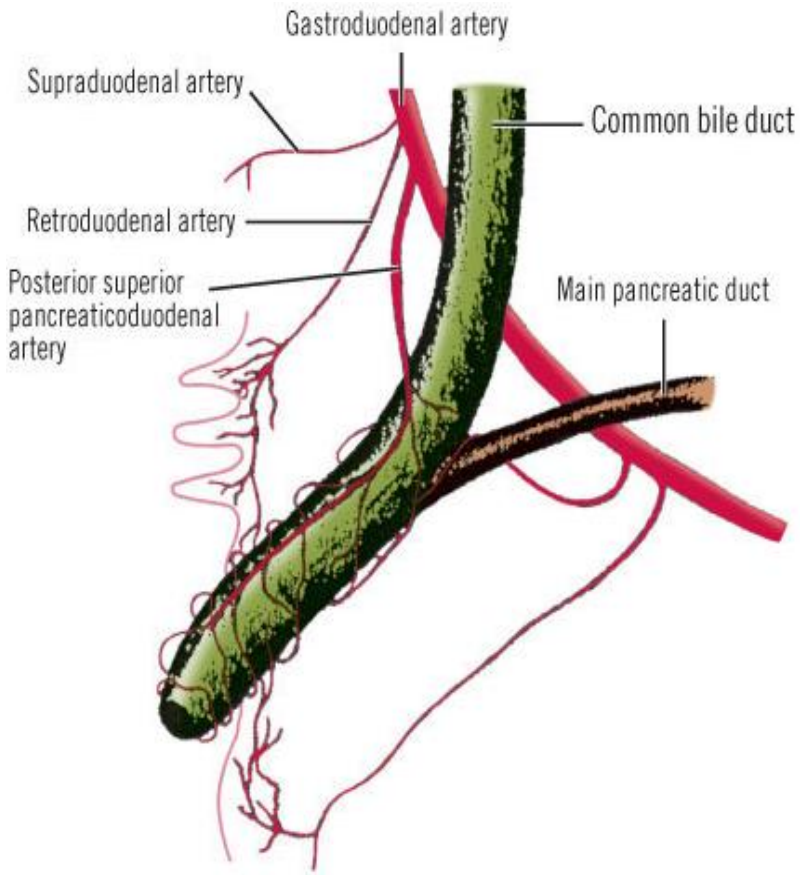
(accessory PD)

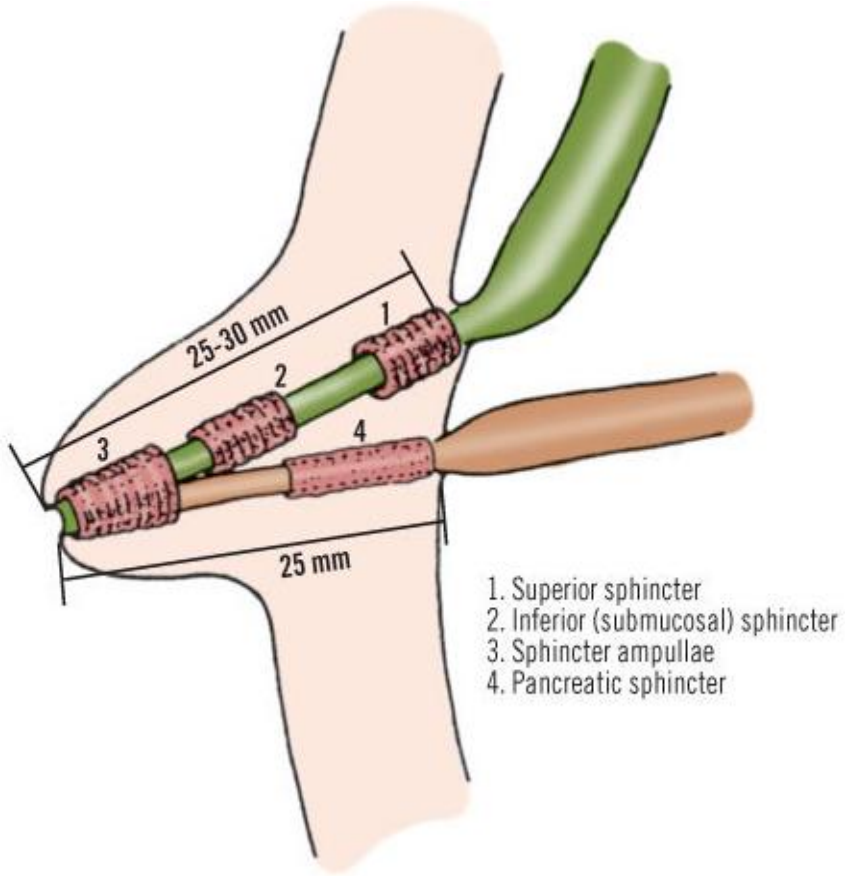
- (anterior part of the head)
- (small duct)

- (2cm superior and anterior of minor papilla



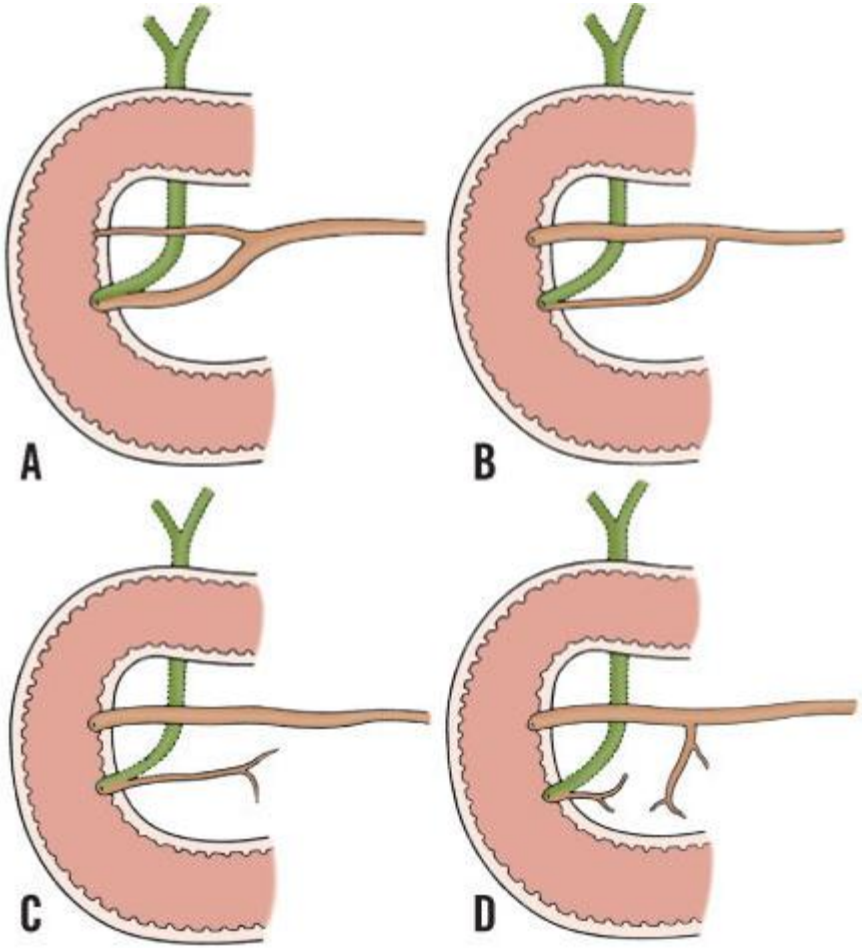
Sphincter of ODDI



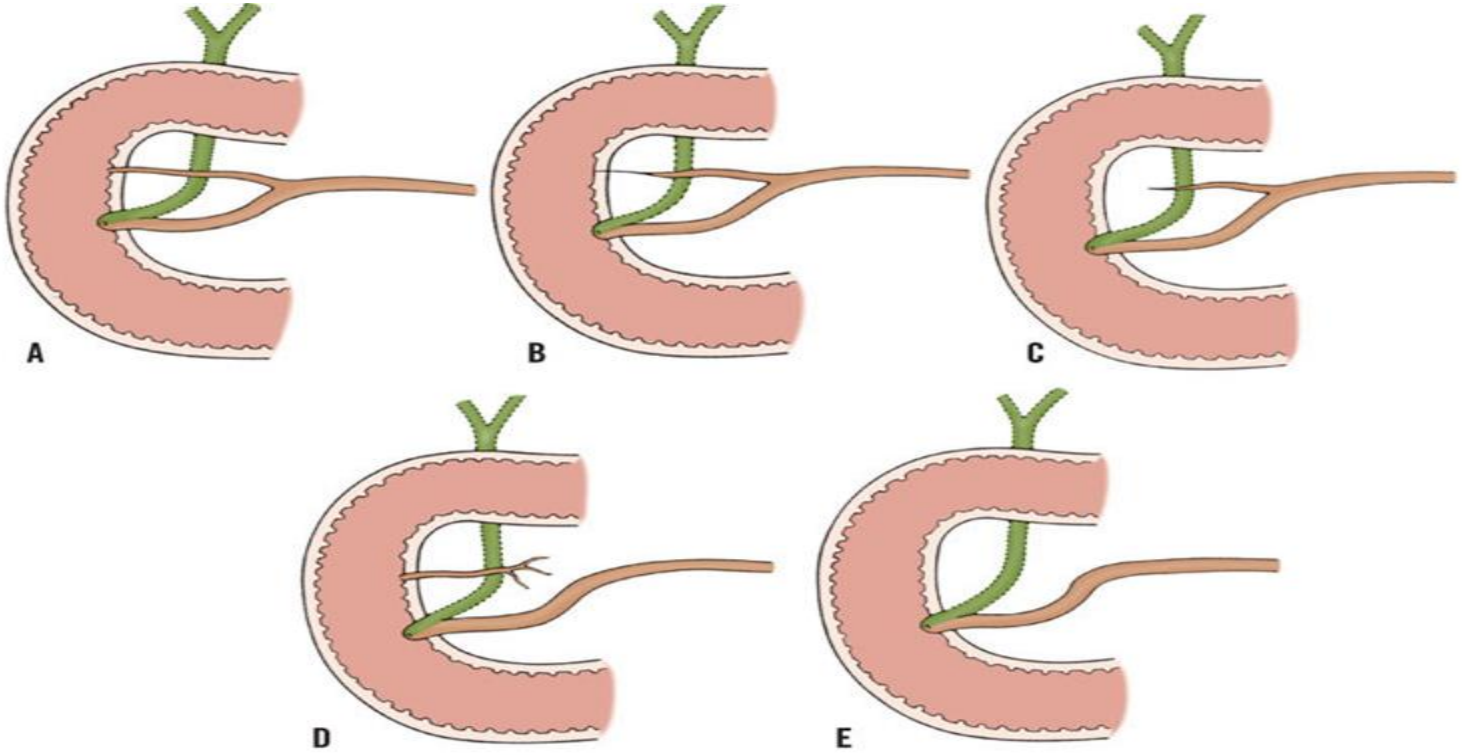


ANATOMICAL VARIATIONS

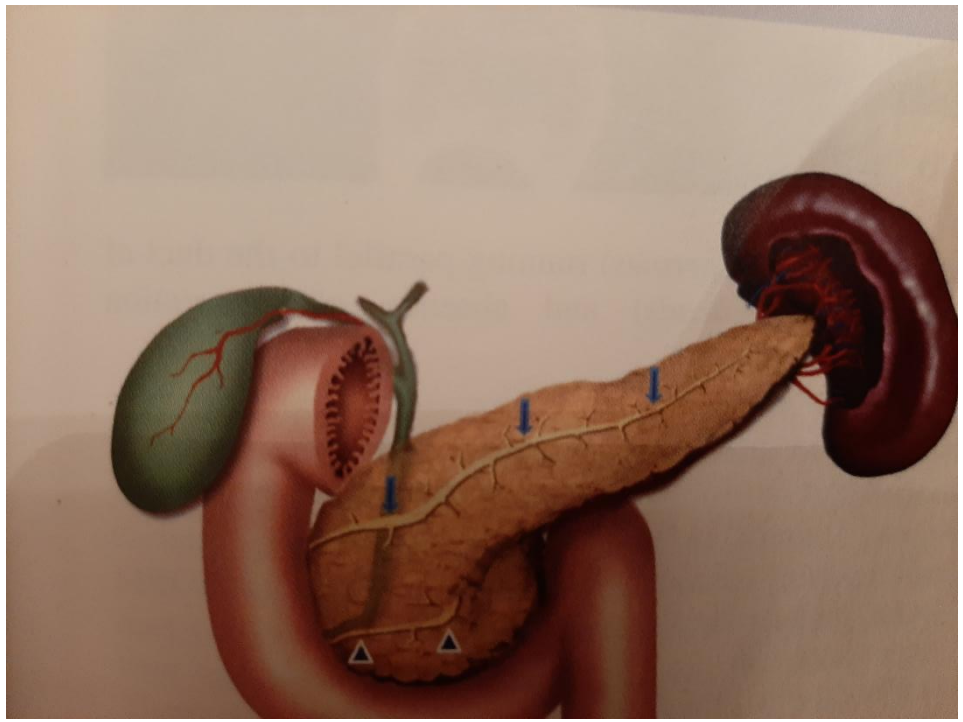
- 10% no connection
- 10%abscence of main duct



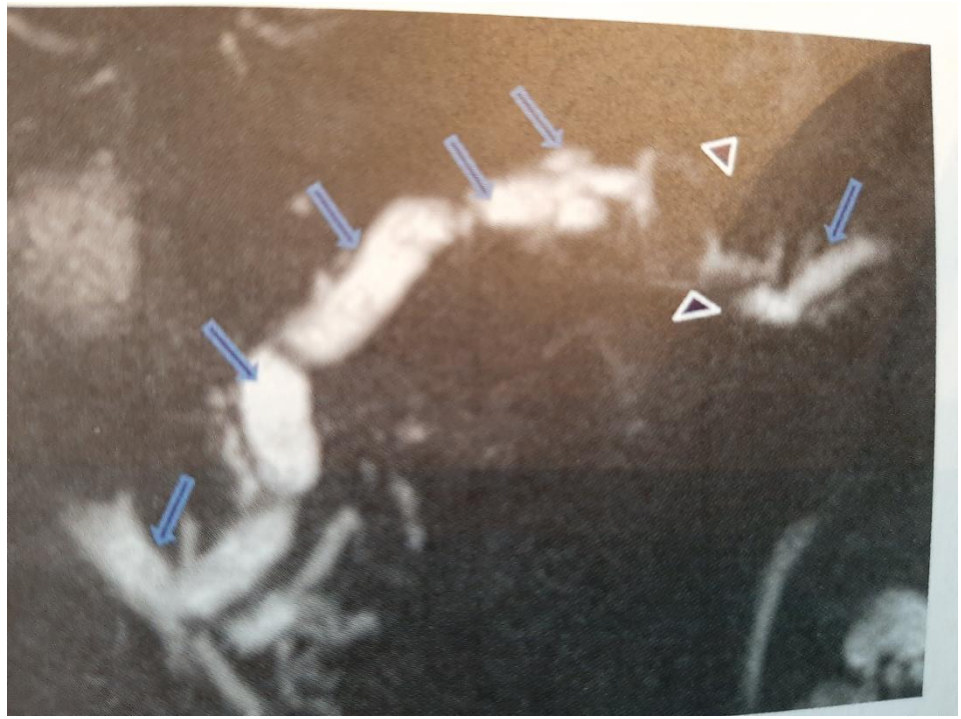
ANATOMICAL VARIATIONS

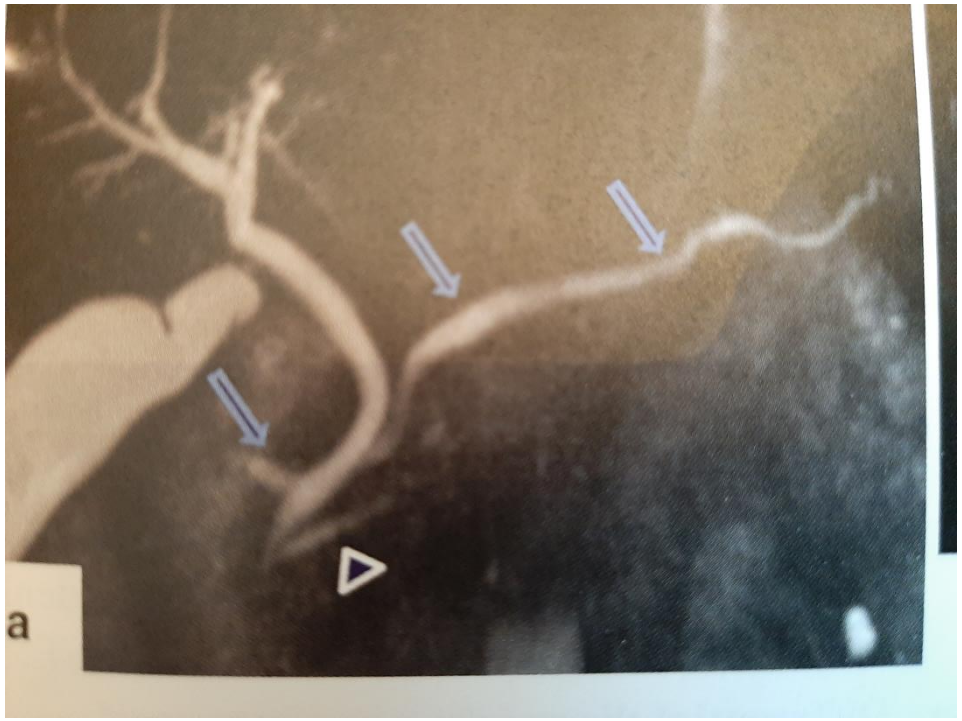


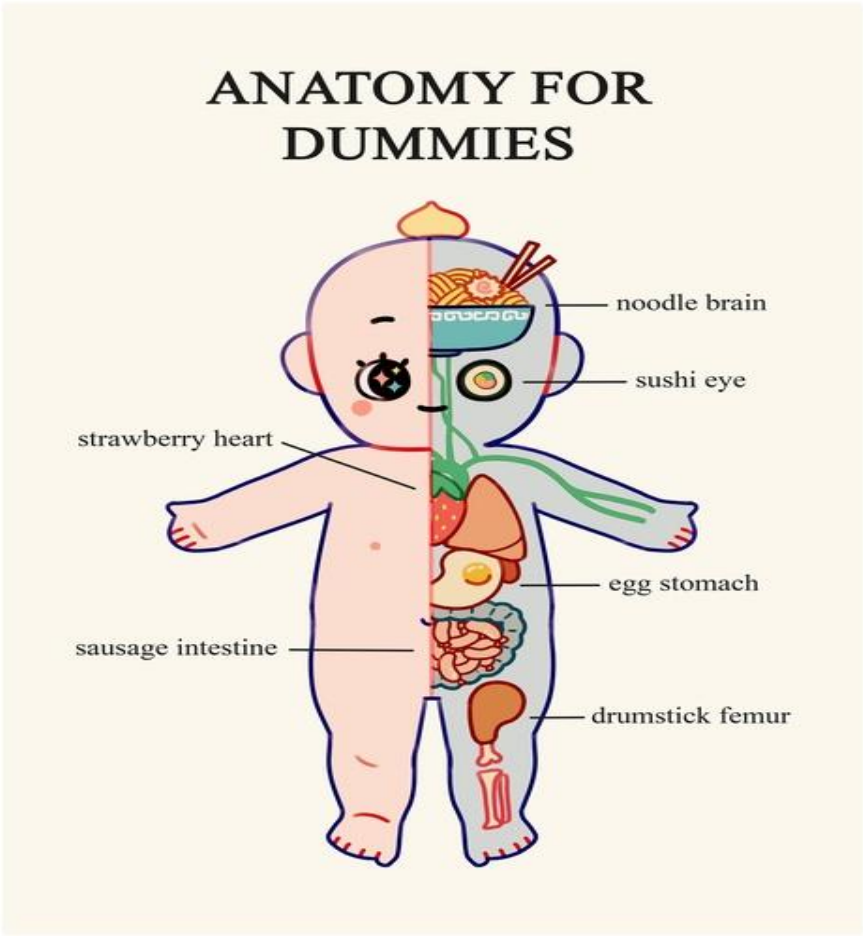
- 60% in the duodenum
- 30% abscence of minor papilla



Pancreas Divisum






ANATOMY FOR DUMMIES
noodle brain
sushi eye
strawberry heart
egg stomach
sausage intestine
drumstick femur

- Thank you