Extrahepatic Biliary Tract

14

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Anatomy

Right, Left, and Common Hepatic Ducts

The right and left hepatic ducts join soon after emerging from the liver to form the common hepatic duct (Fig. 14.1b). The junction lies 0.25–2.5 cm from the surface of the liver. The left duct is longer (1.7 cm, average) and has a longer extrahepatic course than the right duct (0.9 cm, average). In some cases, intrahepatic junction of the hepatic ducts is the result of liver enlargement (Fig. 14.1a); retraction of the liver may then be necessary to expose the junction.

Measurements of the common hepatic duct are highly variable. The duct is said to be absent if the cystic duct enters at the junction of the right and left hepatic ducts (Fig. 14.1c). In most individuals, the duct is between 1.5 and 3.5 cm long.

Three types of cystohepatic junction have been described: angular (Fig. 14.1a, b), parallel (Fig. 14.2a), and spiral (Fig. 14.2b, c).

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L. J. Skandalakis (ed.), *Surgical Anatomy and Technique*,
https://doi.org/10.1007/978-3-030-51313-9_14

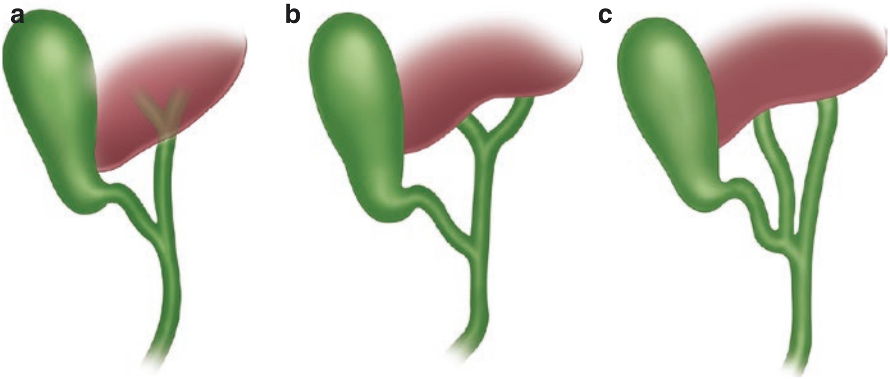


Fig. 14.1 Variations of the hepatic ducts. (**a**) Intrahepatic union of left and right hepatic ducts; (**b**) usual extrahepatic union of left and right hepatic ducts; (**c**) distal union of hepatic ducts producing absence of the common hepatic duct

Anomalous Hepatic Ducts: Surgically Significant Sources of Bile Leakage (Fig. 14.3)

An aberrant hepatic duct is a normal segmental duct that joins the biliary tract just outside the liver instead of just within; it drains a normal portion of the liver. Such a duct passing through the hepatocystic triangle is important because it is subject to inadvertent section with subsequent bile leakage (Fig. 14.3).

Subvesicular bile ducts, found in approximately 35% of individuals, are small blind ducts emerging from the right lobe of the liver and lying in the bed of the gallbladder. They do not communicate with the gallbladder.

Hepatocystic ducts drain bile from the liver directly into the body of the gallbladder or into the cystic duct.

Occasionally, the right, left, or even both hepatic ducts enter the gallbladder. This is an argument in favor of removing the gallbladder at the fundus, from above downward.

Cystic Duct

The cystic duct is about 3 mm in diameter and about 2–4 cm long. If surgeons are unprepared for a short duct (Fig. 14.2e), they may find themselves inadvertently entering the common bile duct. If they underestimate the length, they may leave too long a stump, predisposing to the cystic duct remnant syndrome.

Very rarely, the cystic duct is absent, and the gallbladder opens directly into the common bile duct. In such a case, the common bile duct might be mistaken for the cystic duct.

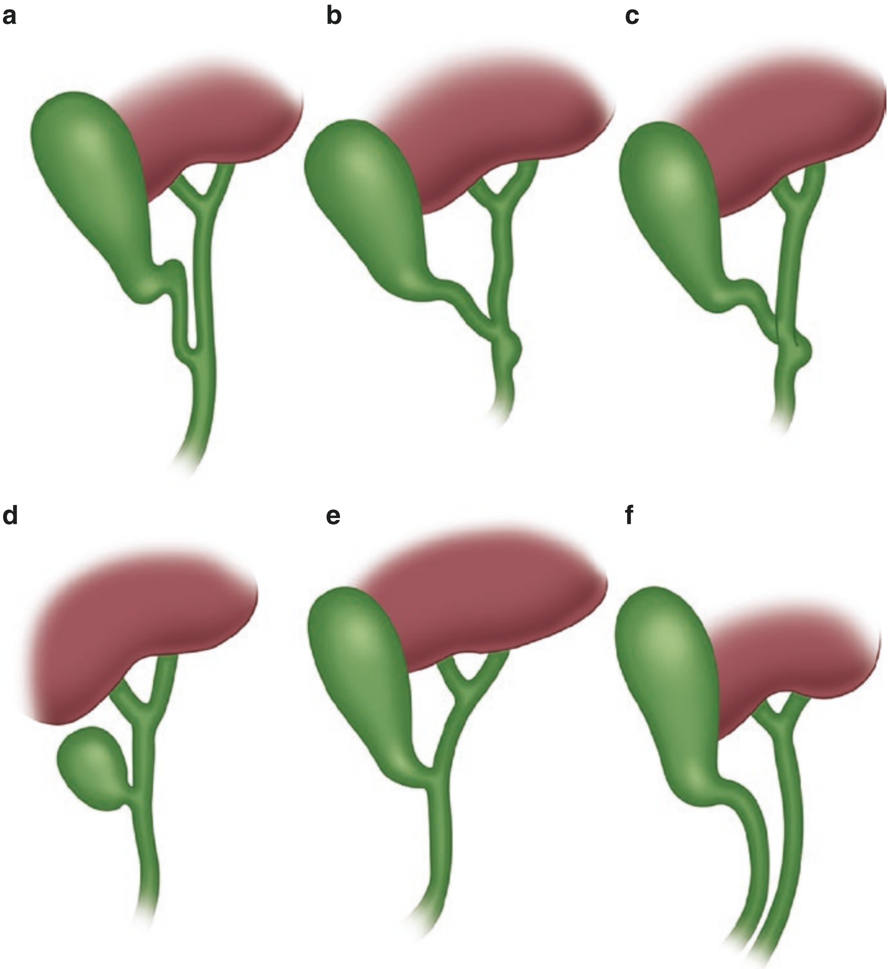


Fig. 14.2 Types of cystohepatic junction. (**a**) Parallel type. (**b, c**) Spiral types. (**d, e**) Short cystic ducts. (**f**) A long cystic duct ending in the duodenum. This may also be called "absence of the common bile duct"

Gallbladder

The gallbladder is located on the visceral surface of the liver in a shallow fossa at the plane dividing the right lobe from the medial segment of the left lobe (the GB-IVC line). The gallbladder is separated from the liver by the connective tissue of Glisson's capsule. Anteriorly, the peritoneum of the gallbladder is continuous with that of the liver, and the fundus is completely covered with peritoneum.

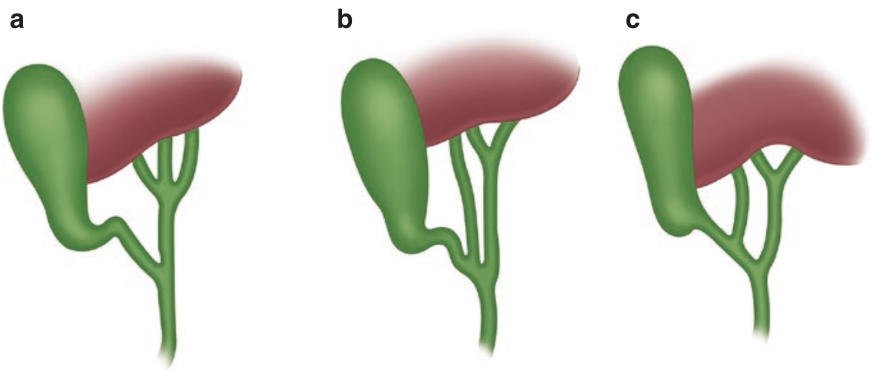


Fig. 14.3 Accessory hepatic ducts. (**a**) Accessory duct joins the common duct along with the usual left and right hepatic ducts. (**b**) Accessory duct joins at the intersection of the cystic duct. (**c**) Accessory duct enters the cystic duct directly. Additional, minute hepatic ducts are not unusual

The body of the gallbladder is in contact with the first and second portions of the duodenum. The body is also related to the transverse colon. Only in the rare presence of a mesentery (wandering gallbladder), a prerequisite for acute torsion, is the body completely covered by peritoneum. Several other anomalous peritoneal folds connected with the body of the gallbladder – cholecystogastric, cholecystoduodenal, and cholecystocolic – are redundancies of the lesser omentum.

The infundibulum is the angulated posterior portion of the body between the neck and the point of entrance to the cystic artery. When this portion is dilated, with eccentric bulging of its medial aspect, it is called a Hartmann's pouch. When this pouch achieves considerable size, the cystic duct arises from its upper left aspect rather than from what appears to be the apex of the gallbladder. The pouch is often associated with chronic or acute inflammation due to lithiasis and often accompanies a stone impacted in the infundibulum.

The neck of the gallbladder is S-shaped and lies in the free border of the hepatoduodenal ligament. The mucosa lining the neck is a spiral ridge said to be a spiral valve, but not to be confused with the spiral valve of the cystic duct (the valve of Heister).

A deformity of the gallbladder seen in 2–6% of individuals is the Phrygian cap (Fig. 14.4a). Hartmann's pouch (Fig. 14.4b) is probably a normal variation rather than a true deformity.

Common Bile Duct

The length of the common bile duct begins at the union of the cystic and common hepatic ducts and ends at the papilla of Vater in the second part of the duodenum. It varies from 5 to 16 cm depending on the actual position of the ductal union. The duct can be divided into four portions (Fig. 14.5): supraduodenal, retroduodenal, pancreatic, and intramural (intraduodenal).

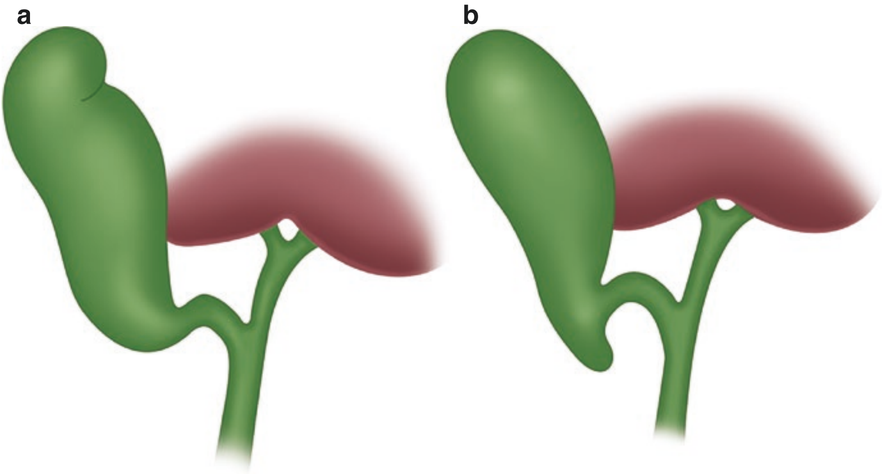


Fig. 14.4 Deformities of the gallbladder. (**a**) “Phrygian cap” deformity; (**b**) Hartmann’s pouch

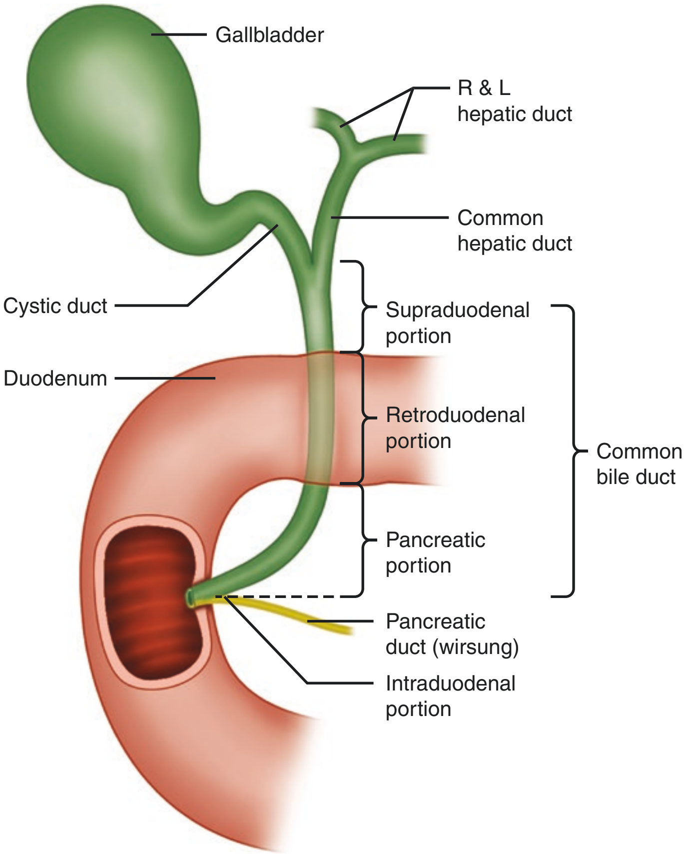


Fig. 14.5 The extrahepatic biliary tract and the four portions of the common bile duct

The supraduodenal portion lies between the layers of the hepatoduodenal ligament in front of the epiploic foramen of Winslow, to the right or left of the hepatic artery, and anterior to the portal vein.

The retroduodenal portion is between the superior margin of the first portion of the duodenum and the superior margin of the head of the pancreas. The gastroduodenal artery lies to the left. The posterior superior pancreaticoduodenal artery lies anterior to the common bile duct. The middle colic artery lies anterior to the duct and other arteries.

The common bile duct may be partly covered by a tongue of pancreas (44%) (Fig. 14.6a, b); completely within the pancreatic substance (30%) (Fig. 14.6c); uncovered on the pancreatic surface (16.5%) (Fig. 14.6d); or completely covered by two tongues of pancreas (9%) (Fig. 14.6e). Even when completely covered, the groove or tunnel occupied by the duct may be palpated by passing the fingers of the left hand behind the second part of the duodenum after mobilization with the Kocher maneuver.

The normal outside diameter of the first three regions of the common bile duct is variable, but a common bile duct more than 8 mm in diameter is considered enlarged and, therefore, pathological. Radiological studies in asymptomatic patients demonstrate an increase 0.3 mm increase in CBD diameter for every decade of life after age 20 with average CBD diameter being 4 mm (based on end-expiration MRCP images).

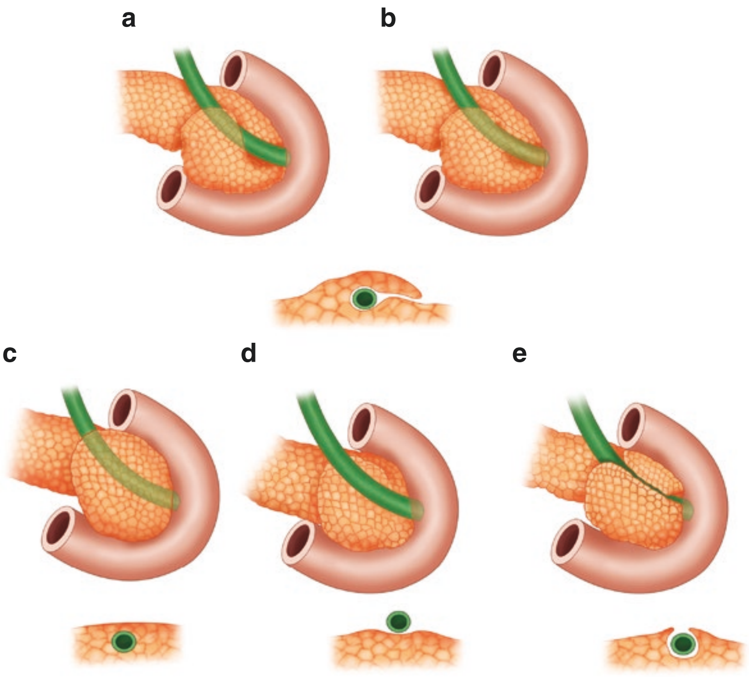


Fig. 14.6 Relation of the pancreas and the common bile duct. (**a, b**) The duct is partially covered by a tongue of pancreas (44%). (**c**) The duct is completely covered by the pancreas (30%). (**d**) The duct lies free on the surface of the pancreas (16.5%). (**e**) The duct is covered by two tongues of pancreas with a cleavage plane between

The fourth, or intramural (sometimes called intraduodenal), portion of the common bile duct (see Fig. 9.9) passes obliquely through the duodenal wall together with the main pancreatic duct. Within the wall, the length averages 15 mm. As it enters the wall, the common duct decreases in diameter. The two ducts usually lie side by side with a common adventitia for several millimeters. The septum between the ducts reduces to a thin mucosal membrane before the ducts become confluent (see Chap. 9).

Hepatocystic Triangle and Triangle of Calot

The hepatocystic triangle is formed by the proximal part of the gallbladder and cystic duct to the right, the common hepatic duct to the left, and the margin of the right lobe of the liver superiorly (Fig. 14.7). The triangle originally described by Calot defined the upper boundary as the cystic artery. The area included in the triangle has enlarged over the years to include the lower edge of the right lobe as the superior, the common hepatic duct as the medial, and the cystic duct as the inferior-lateral boundaries. Within the boundaries of the triangle as it is now defined are several structures that must be identified before they are ligated or sectioned.

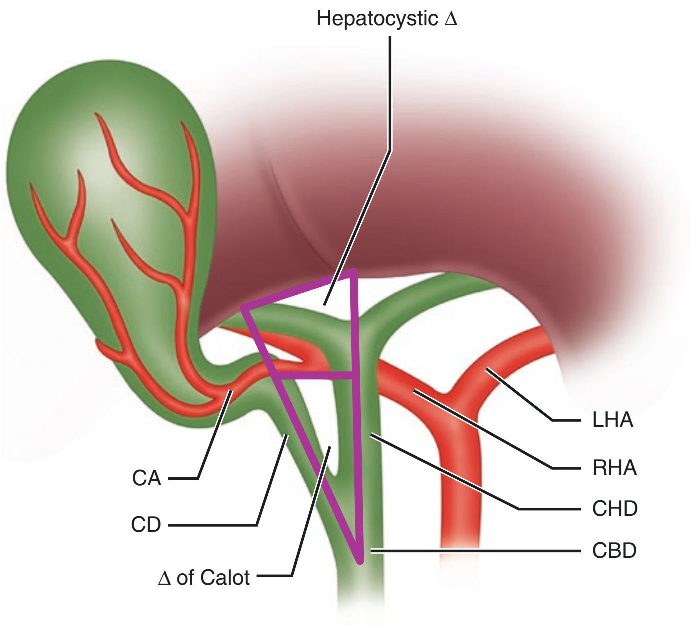


Fig. 14.7 The hepatocystic triangle and the triangle of Calot. The upper boundary of the hepatocystic triangle is the margin of the liver; that of the triangle of Calot is the cystic artery; the triangle of Calot is stippled. *CA* cystic artery, *CD* cystic duct, *CBD* common bile duct, *RHA* right hepatic artery, *LHA* left hepatic artery, *CHD* common hepatic duct

The hepatocystic triangle contains the right hepatic artery (and sometimes an aberrant right hepatic artery), the cystic artery, and sometimes an aberrant (accessory) bile duct.

In 87% of individuals, the right hepatic artery enters the triangle posterior to the common hepatic duct, and in 13% it enters anterior to it. In one study of cadavers, the right hepatic artery could have been mistaken for the cystic artery 20% of the time. As a rule of thumb, any artery more than 3 mm in diameter within the triangle will probably not be a cystic artery.

In 18%, there was an aberrant right hepatic artery. In 83% of these specimens, the cystic artery arose from the aberrant artery within the triangle. In 4%, the aberrant artery was accessory to a normal right hepatic artery, and in 14%, it was a replacing artery, the only blood supply to the right lobe of the liver (see Fig. 13.8).

The cystic artery usually arises from the right hepatic artery or an aberrant right hepatic artery within the hepatocystic triangle. At the neck of the gallbladder, the cystic artery divides into a superficial and a deep branch (Table 14.1).

In 16%, there were aberrant (accessory) bile ducts within the hepatocystic triangle that may cause bile to leak into the abdominal cavity.

Vascular System of the Extrahepatic Biliary Tract

Arterial Supply

In general, the major blood vessels to the extrahepatic biliary tree are posterior to the ducts, but in several cases they may lie anteriorly. The surgeon must recognize and preserve these arteries. Table 14.2 shows the frequency with which specific arteries are found anterior to segments of the biliary tract.

Table 14.1 Origin of the cystic artery

Origin	Percent
Right hepatic artery	
Normal	61.4
Aberrant (accessory)	10.2
Aberrant (replacing)	3.1
Left hepatic artery	5.9
Bifurcation of common hepatic artery	11.5
	92.1
Common hepatic artery	3.8
	95.9
Gastroduodenal artery	2.5
Superior pancreaticoduodenal artery	0.15
Right gastric artery	0.15
Celiac trunk	0.3
Superior mesenteric artery	0.9
Right gastroepiploic artery	Rare
Aorta	Rare
	99.9

Data from BJ Anson. Anatomical considerations in surgery of gallbladder. *Q Bull Northwest Univ Med School*. 1956;30:250

The gallbladder is supplied by the cystic artery. The bile ducts are supplied by branches of the posterior superior pancreaticoduodenal, retroduodenal, and right and left hepatic arteries. Do not devascularize more than 2–3 cm of the upper surface of the duct (Fig. 14.8).

Table 14.2 Segments of the biliary tract and the frequency of arteries lying anterior to them

Segment	Artery anterior	Percent frequency
Right and left hepatic ducts	Right hepatic artery	12–15
	Cystic artery	<5
Common hepatic duct	Cystic artery	15–24
	Right hepatic artery	11–19
	Common hepatic artery	<5
Supraduodenal common bile duct	Anterior artery to common bile duct	50
	Posterior superior pancreaticoduodenal artery	12.5
	Gastroduodenal artery	5.7–20[a]
	Right gastric artery	<5
	Common hepatic artery	<5
	Cystic artery	<5
	Right hepatic artery	<5
Retroduodenal common bile duct	Posterior superior pancreaticoduodenal artery	76–87.5
	Supraduodenal artery	11.4

Data from Johnson and Anson. *Surg Gynecol Obstet* 1952;94:669 and Maingot (ed.), *Abdominal Operations*, 6th ed. Norwalk, CT: Appleton & Lange, 1974

[a]In another 36%, the gastroduodenal artery lay on the left border of the common bile duct

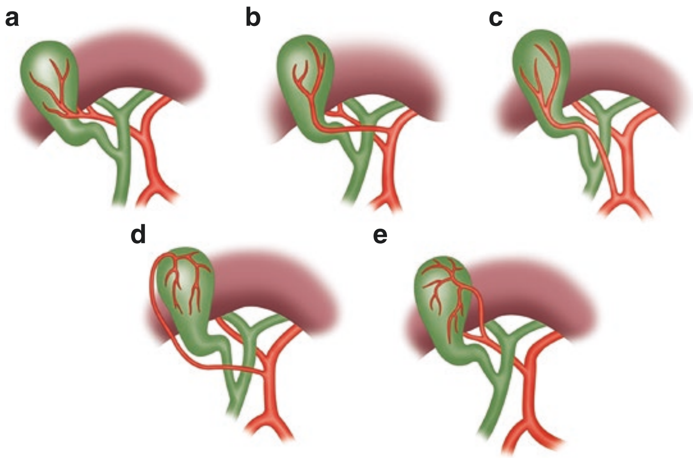


Fig. 14.8 Some possible origins of the cystic artery. (**a**) Usual pattern (74.7%) from the right normal or aberrant hepatic artery. (**b**) Origin from the common hepatic artery, its bifurcation, or from the left hepatic artery and crossing in front of the common hepatic duct (20.5%). (**c**) Origin from the gastroduodenal artery (2.5%). The remainder arises from a variety of sources. (**d, e**) Very rarely the cystic artery reaches the gallbladder at the fundus or body ("recurrent" cystic artery)

The blood supply of the supraduodenal common bile duct is essentially axial. The major supply comes from below (60% from the retroduodenal artery), and 38% comes from above (from the right hepatic artery). The bile ducts in the hilum and the retropancreatic bile duct have an excellent blood supply.

Ischemia of the bile duct can be avoided with a high or low transection, but bleeding of the edges should be checked prior to anastomosis.

Venous Drainage

Several cystic veins, rather than one, enter the hepatic parenchyma (Fig. 14.9).

An epicholodochal venous plexus helps the surgeon identify the common bile duct. Remember that stripping of the common bile duct is not permissible.

Lymphatic Drainage

Collecting lymphatic trunks from the gallbladder drain into the cystic node in the crotch of the junction of the cystic and common hepatic ducts to the "node of the hiatus" and posterior pancreaticoduodenal nodes (Fig. 14.10).

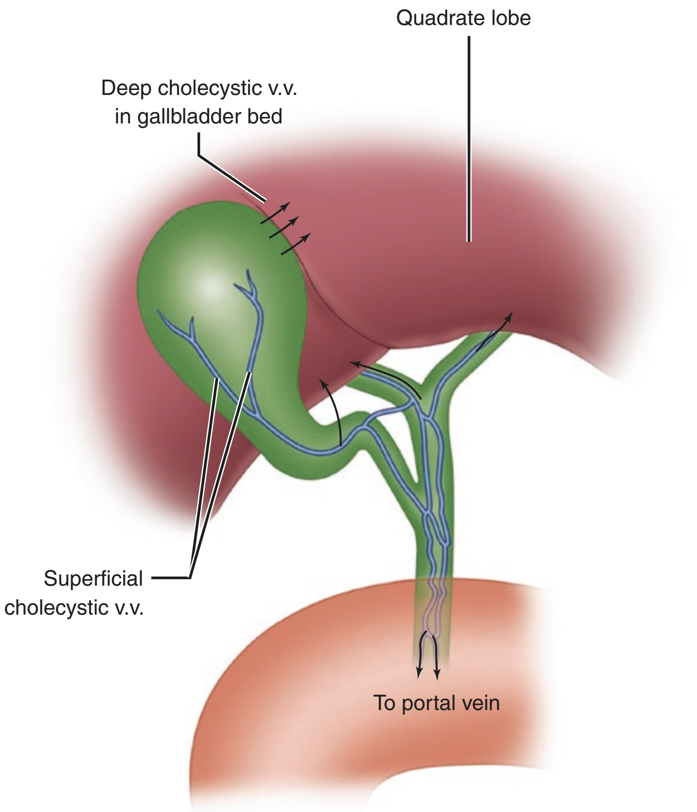


Fig. 14.9 Venous drainage of the biliary tract. Most of the drainage is from the gallbladder bed into the quadrate lobe of the liver. Veins of the duct system drain upward to the liver and downward to the portal vein

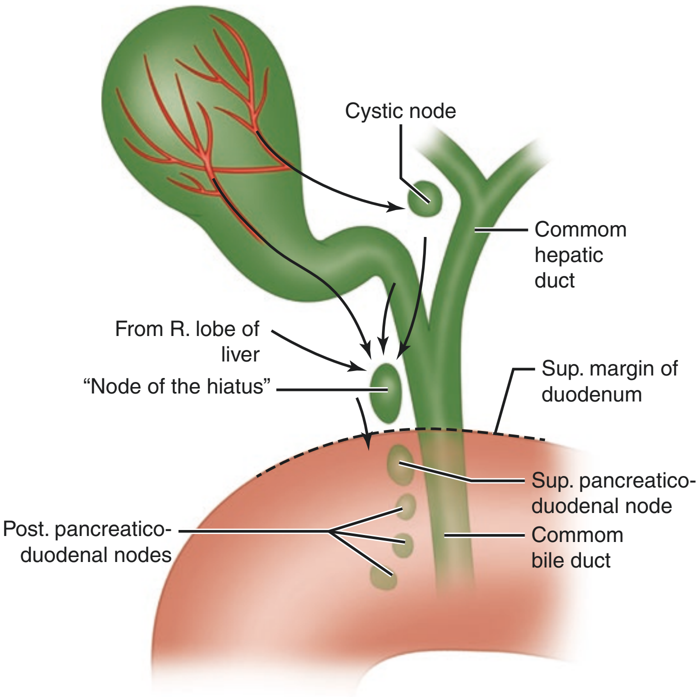


Fig. 14.10 Lymphatic drainage of the biliary tract. The cystic node and the node of the hiatus are relatively constant. Drainage from the gallbladder, the cystic duct, and the right lobe of the liver reaches the posterior pancreaticoduodenal nodes

The pericholedochal nodes receive lymphatics from the extrahepatic bile ducts and from the right lobe of the liver.

Technique

Cholecystectomy

Three procedures for cholecystectomy are presented: (1) laparoscopic (robotic) cholecystectomy, (2) removal of the gallbladder from above downward, and (3) removal of the gallbladder from below upward

Laparoscopic and Robotic Cholecystectomy

Figure 14.11 shows port placement. Functions of each port follow (Table 14.3):

Procedure
Position: Supine on X-ray operating room table
Anesthesia: General
Other: Knee-high pneumatic apparatus. Foley catheter and nasogastric tube placement is not routinely recommended and should be tailored to expected level of case difficulty and operative time.

- **Step 1.** Using a No. 10 scalpel blade, make a longitudinal 5-mm incision in the umbilical area long enough to permit the entrance of a 5-mm trocar.
- **Step 2.** Insert a Veress needle into the peritoneal cavity at a 45-degree angle toward the pelvic cavity. This may be facilitated with upward traction of the abdominal wall using two towel clamps on each side of the incision. Aspirate with a 10–20-cm^3 syringe, and if there is no return with the aspiration, inject normal saline through the syringe.
  Alternatively an open Hasson approach may also be utilized for gaining access to the peritoneal cavity by dissecting down to the rectus sheath and lifting it with Kocher clamps. An incision is made between the clamps and 10-mm trocar inserted under direct visualization.

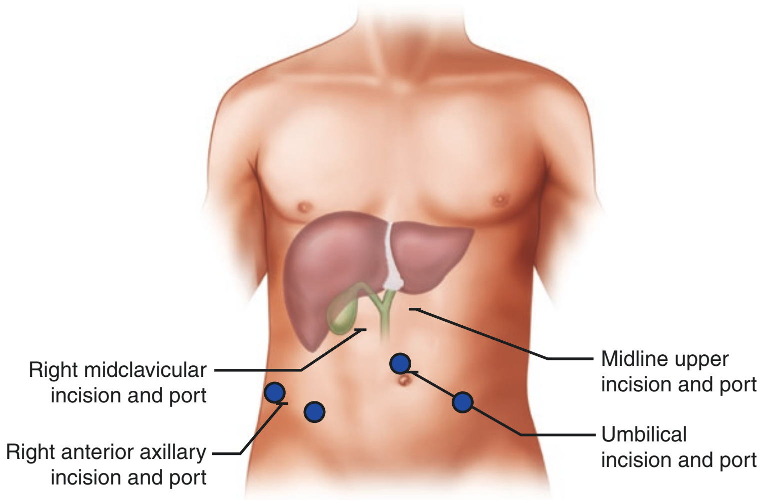


Fig. 14.11 Sites of incisions and ports. For robotic cholecystectomy, we recommend moving the right midclavicular port to the midpoint of the line between the umbilical port and the right anterior axillary line port. The midline upper port can be moved to the left abdomen to mirror the contralateral midclavicular port. The closed blue circles represent one iteration of the working ports for a robotic cholecystectomy

Table 14.3 Laproscopic cholecystectomy port placement

Umbilical	Laparoscopic examination of the peritoneal cavity; gallbladder localization; removal of the gallbladder
Upper midline	Surgical dissection of the gallbladder and partially of the hepatic triad at the hilum; clips may be accommodated through this port
Right anterior axillary line	Retraction of the gallbladder
Right midclavicular line	Retraction of the gallbladder

- **Step 3.** If normal saline is easily injected, insufflate CO_2.

Remember
- During insufflation, the intraperitoneal pressure should be 0–5 mm, except when the Veress needle is not well placed. With obesity, initial pressure may be a little higher.

- **Step 4.** If abdominal distention is satisfactory, proceed with the following "trocar steps," for robotic cholecystectomy see Fig. 14.11 for the suggested port placement.
  (a) Insert a 5-mm trocar at the umbilical area at a 45-degree angle cephalad.
  (b) Insert the laparoscope with the attached camera.
  (c) erform laparoscopic inspection and begin exploration for any gross pathology.
  (d) Visualize the gallbladder.
  (e) Under direct vision, insert a 5-mm trocar through the incision at the upper midline or to the right of the midline or a similar incision. The need for narrow or wide costal margins and the patient's length of trunk should be considered because low placement will clash with the laparoscope, while in high placement the liver will interfere with dissection.
  (f) Also under direct vision, place the remaining two 5-mm trocars at the right anterior axillary line and the right midclavicular line.
  (g) Set the table in reverse Trendelenburg with rolling to the left.
- **Step 5.** Retract the dome of the gallbladder anteriorly and upward by grasping the fundus with the port of the anterior axillary line. Grasp Hartmann's pouch with the port at the midclavicular line and retract laterally (Fig. 14.12).
- **Step 6.** Dissect and visualize the cystic duct and common bile duct. Begin dissection by incising the peritoneal reflections both medially and laterally to the gallbladder. If a cholangiogram is required, it may be done through the cystic duct prior to its ligation.
- **Step 7.** Make sure to visualize the critical view of safety. The three components needed to achieve CVS are (1) the hepatocystic triangle is cleared of fat and fibrous tissue. (2) The lower one third of the gallbladder is separated from the liver to expose the cystic plate. (3) Two and only two structures should be seen

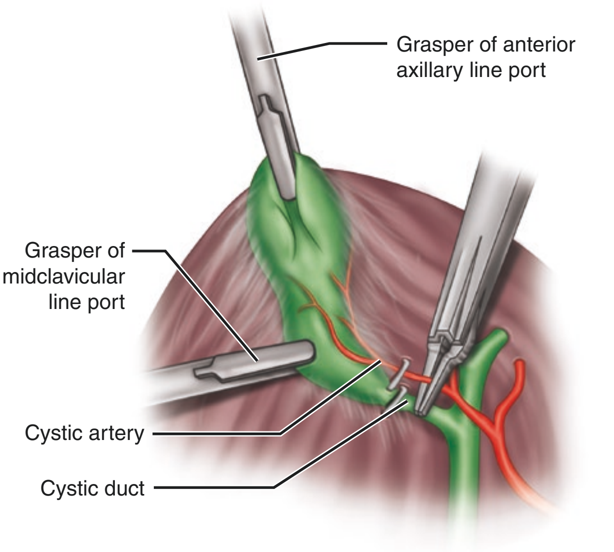


Fig. 14.12 Gallbladder is raised. Hartman's pouch is retracted laterally

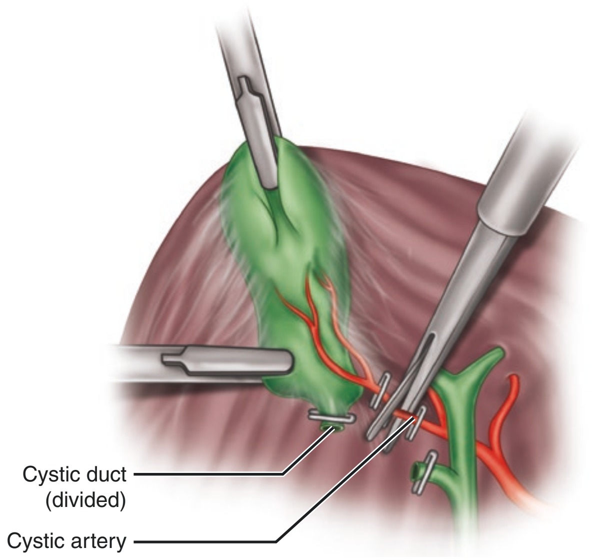


Fig. 14.13 Ligation and division of cystic artery and cystic duct

entering the gallbladder. The doublet view (anterior and posterior visualization should be utilized to demonstrate the CVS).

- **Step 8.** Carefully ligate the cystic artery and cystic duct by proximal and distal clipping. Divide both entities (Figs. 14.12 and 14.13).
- **Step 9.** Dissect the gallbladder from the liver using the "hook" electrocautery (Fig. 14.14).

- **Step 10.** Slowly and carefully separate the gallbladder from its bed. Obtain hemostasis. Perform repeated irrigations (Fig. 14.15).
- **Step 11.** Remove the gallbladder through the umbilical port. The umbilical incision may be enlarged to permit the cholecystic exodus.

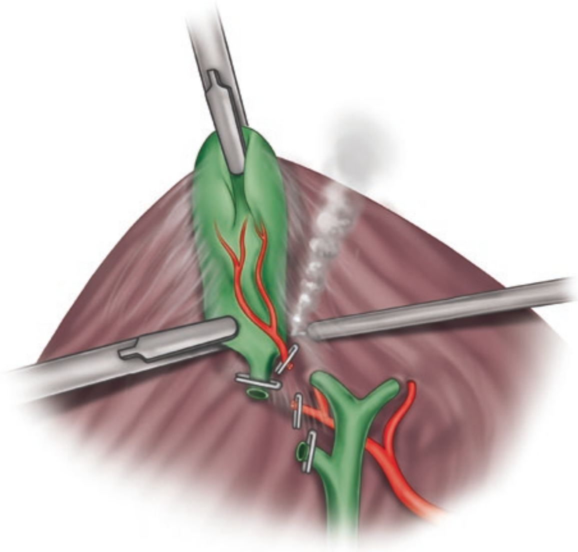


Fig. 14.14 Dissection of gallbladder from the liver

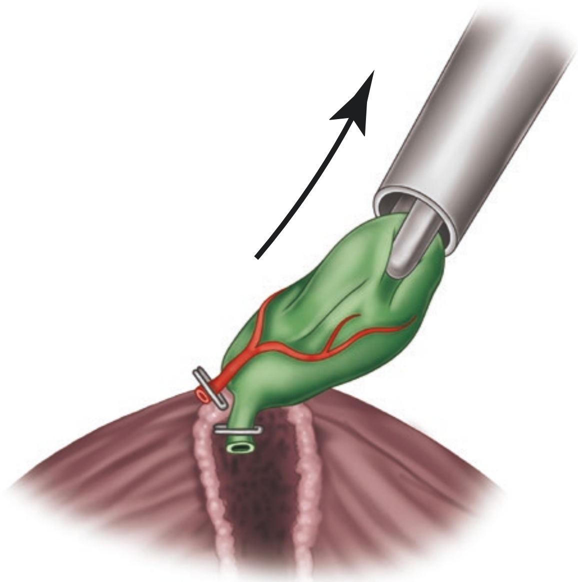


Fig. 14.15 Separating gallbladder from its bed

- **Step 12.** After ascertaining that there is no bleeding, remove all trocars under direct vision.
- **Step 13.** Close the umbilical incision by suturing the fascia and the skin. Close the skin of the other ports.

Fluorescent Visualizations of Biliary Structures Using Near-Infrared Imaging Capability of New Camera Systems

Patients are administered 2.5 mg of indocyanine green (ICG) intravenously at the start of the procedure. Indocyanine green (ICG) is an FDA-approved hydrophilic anionic dye and has an excellent safety profile. During or after cystic plate dissection, the near-infrared functionality of such equipped cameras can be switched on and biliary structures can be very well visualized using this technique. The use of ICG visualization should be considered on every laparoscopic (robotic) case where near-infrared camera capability is available. The biliary structures will appear as bright green (or other colored depending upon manufacturer camera settings) structures against a dark background. Extrahepatic biliary anatomy can be visualized for assisting in safe performance of cholecystectomy. It is extremely important to note that the use of fluorescence imaging does not obviate the need for visualization of the critical view of safety, which needs to be done for each procedure and documented.

Cholecystectomy from Above Downward

Preoperative preparation:

- Prior to incision, intravenous antibiotic of choice
  Anesthesia: General
  Position: Supine on a special X-ray operating room table
  Incision: Right subcostal or other incision of choice
- **Step 1.** Dissect the area of the cystic duct and the common duct. Identify the cystic duct and double pass a 2–0 silk around it. Identify the cystic artery. Ligate proximally and distally with 2–0 silk and divide. If there is any doubt about the identity of the cystic artery, do not divide yet.
- **Step 2.** Using the Bovie, carefully dissect the gallbladder from the liver from above downward until you reach the hepatoduodenal ligament. Inspect the gallbladder fossa for leakage of bile or bleeding and treat using electrocautery (Fig. 14.16).

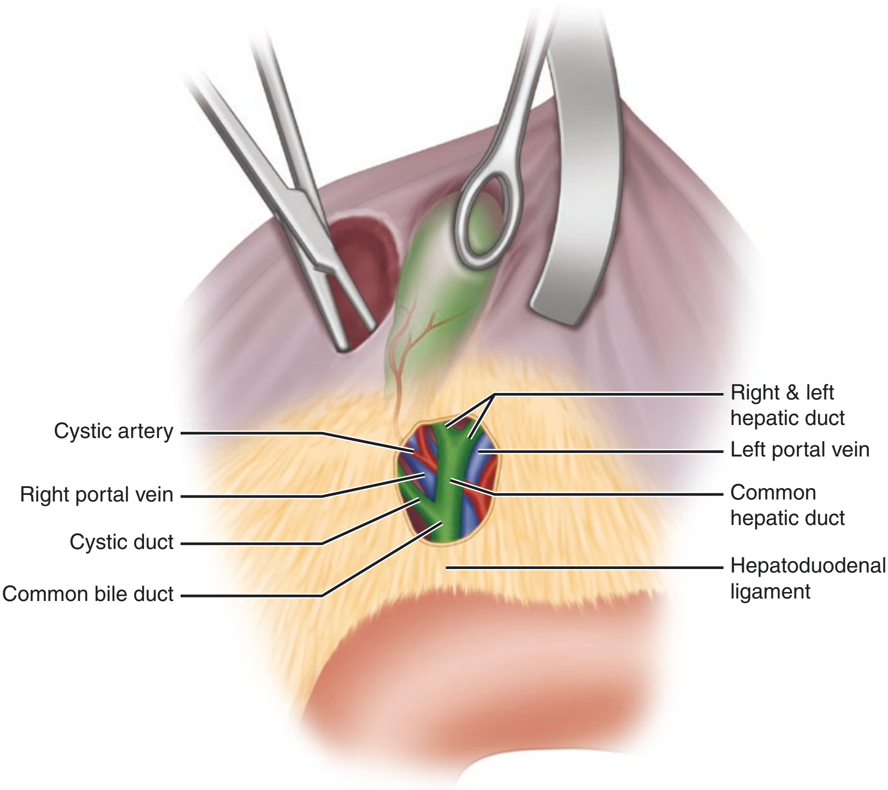


Fig. 14.16 Area of cystic duct and cystic artery is dissected

- **Step 3.** If the cystic artery has not yet been divided, divide it. It should be located near and parallel to the cystic duct (Fig. 14.17).
- **Step 4.** Isolate the cystic duct. Decide whether to perform a cholangiogram. If not, carefully clamp the cystic duct proximally and distally between two clamps. Divide the cystic duct between the clamps and ligate (Fig. 14.18).
- **Step 5.** Remove the specimen and irrigate the gallbladder fossa and right upper quadrant.
- **Step 6.** Decide whether to drain the area. If so, use a Jackson-Pratt drain, bringing it out through a stab wound. Close in layers.

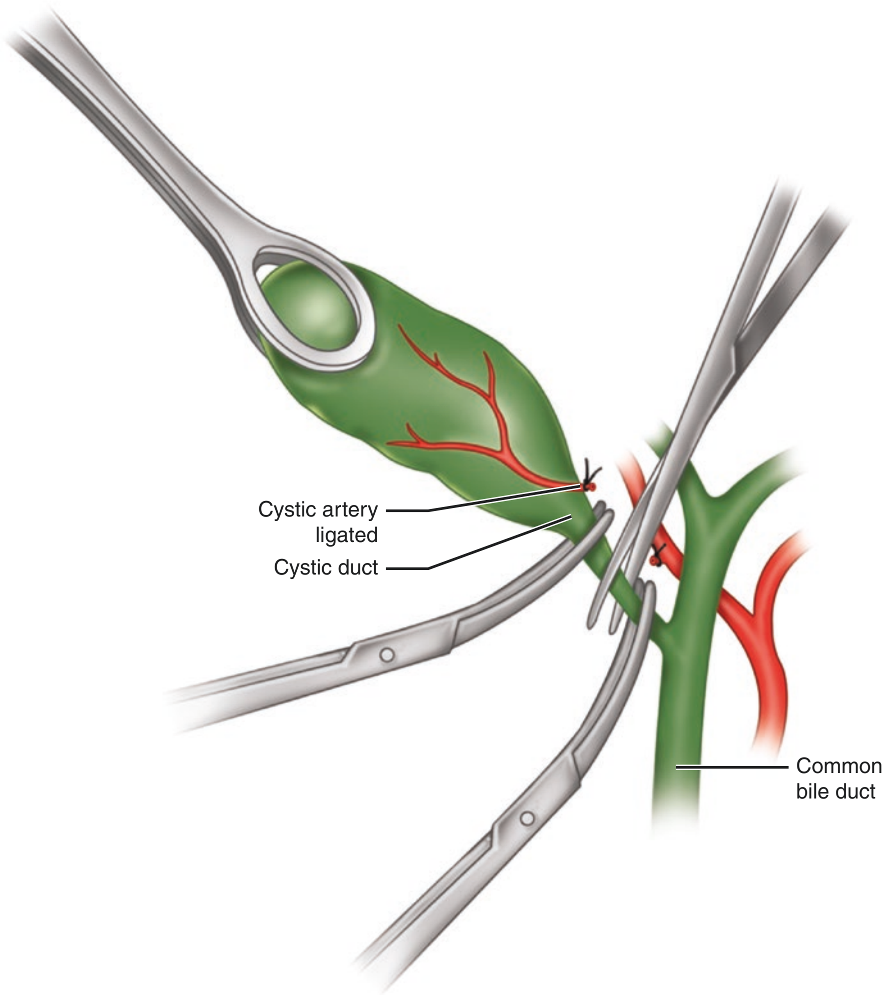


Fig. 14.17 Division of cystic artery

Cholecystectomy from Below Upward

- **Step 1.** Dissect the area of the cystic and common ducts and identify these structures as well as the cystic arteries (Figs. 14.19 and 14.20).
- **Step 2.** Doubly ligate the cystic duct and cystic artery with 2–0 silk. Incise all around the serosa of the gallbladder approximately 1–1½ cm from the liver edge. Using the Bovie and right-angle clamp, dissect the gallbladder from the liver. Upward traction by placing a clamp near the cystic duct (on the gallbladder) is helpful.

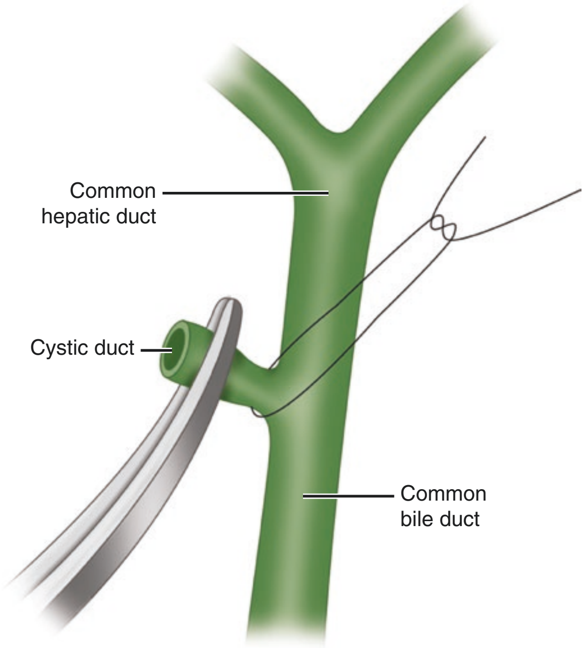


Fig. 14.18 Division of cystic duct

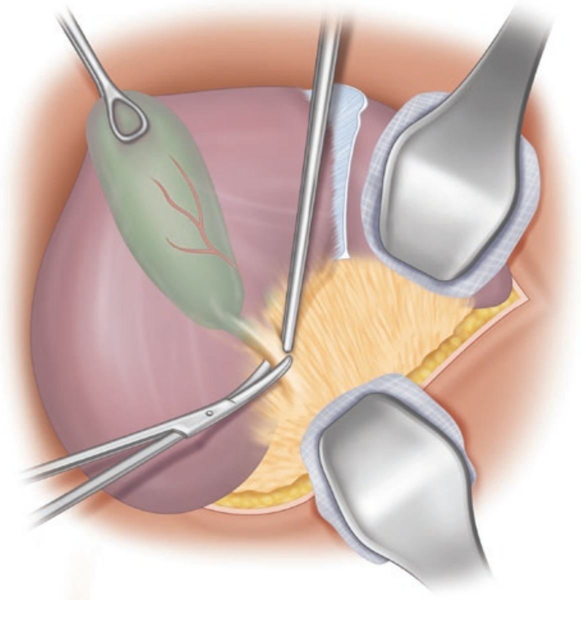


Fig. 14.19 Dissecting area of cystic and common ducts

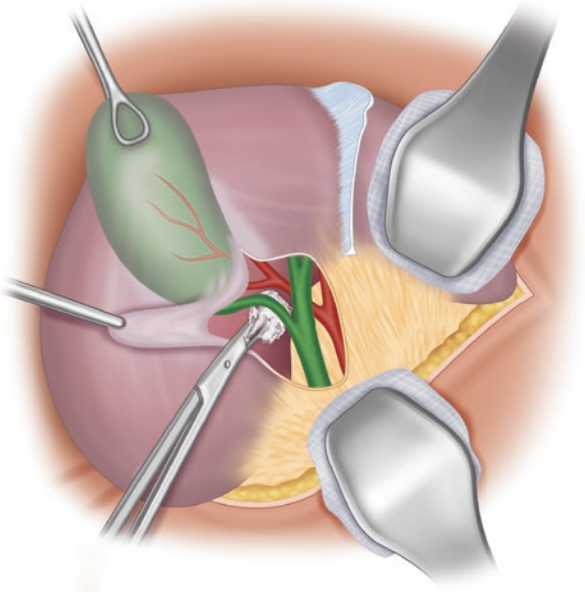


Fig. 14.20 Bed of cystic arteries

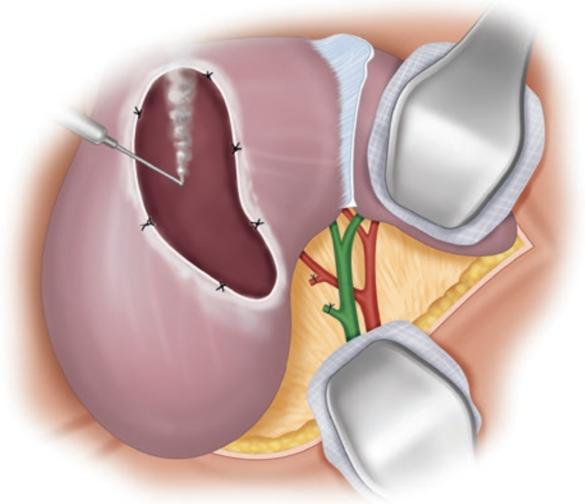


Fig. 14.21 Electrocoagulation of gallbladder fossa

- **Step 3.** Remove the gallbladder and electrocoagulate the gallbladder fossa to stop bleeding or bile leakage (Fig. 14.21).

Operating Room Cholangiogram

To perform an adequate operative cholangiogram, the volume of the biliary tract is more important than the length or the diameter. The capacity is between 12 and 20 ml. Obviously, the presence of stones will markedly reduce the capacity.

Note

- The anterior leaf of the hepatoduodenal ligament is routinely incised over the hepatocystic triangle and the underlying structures are revealed. In more difficult cases, where adhesions from inflammation or previous surgery have obscured normal relationships, greater efforts are required:
  - The hepatic flexure of the colon and the duodenum may be mobilized to the left.
  - The liver may be retracted to the right. This will put slight tension on the biliary ducts and open the epiploic foramen (Winslow's foramen), providing better orientation of the field.
  - In dissecting the gallbladder away from the liver bed, the cystic artery may be exposed by the rotation of the gallbladder to the left. This will also expose the common hepatic duct, the right and left hepatic ducts, and the cystic duct. Being able to perform this maneuver is one of the advantages of removing the gallbladder from the fundus downward.
  - Use suction and Bovie for the bleeding bed. The gallbladder bed may be filled with omentum and a drain placed over the omentum (not between the bed and the omentum).
  - The subserous excision of the gallbladder uses the lamina propria of loose connective tissue as the plane of dissection.
  - Another approach is to identify the cystic artery and duct and then ligate and transect them. The gallbladder may then be dissected from its bed from below upward.
  - Another option is to begin at the fundus of the gallbladder and dissect downward toward the neck with the following steps: (1) dissection of the gallbladder, (2) exposure of the cystic duct and its union with the common bile duct, (3) an operating room cholangiogram, and (4) dissection and ligation of the cystic duct and removal of the gallbladder.
  - Regardless of the direction of the procedure, the junction of the cystic and common hepatic ducts should be identified.

If a cholangiogram is performed, the patient should be rotated slightly to the right so that the common bile duct is rotated off the spine and becomes clearly visible.

An operative cholangiogram will be of great assistance to the surgeon passing a probe through the common bile duct. There is a potential danger if the surgeon passes a probe and expects it to take a straight line to the ampulla and encounters instead a 90-degree turn as the duct enters the duodenum. If the duct is fixed by disease or prior surgery, and if the surgeon is a little too rough, perforation can result.

- **Step 1.** For traction, use mild tension on the proximal ligation of the cystic duct (which, though ligated, is still connected to the gallbladder). Make a minute opening into the anterior wall of the cystic duct with a No. 11 blade (Fig. 14.22). Through this opening, insert a Reddick balloon catheter. It is secured by inflating the balloon.
- **Step 2.** Take two X-rays: the first after injecting 7 cm^3 of 30% Renografin and the second using 14 cm^3 of contrast. Have the anesthesiologist stop ventilating the patient during exposure.

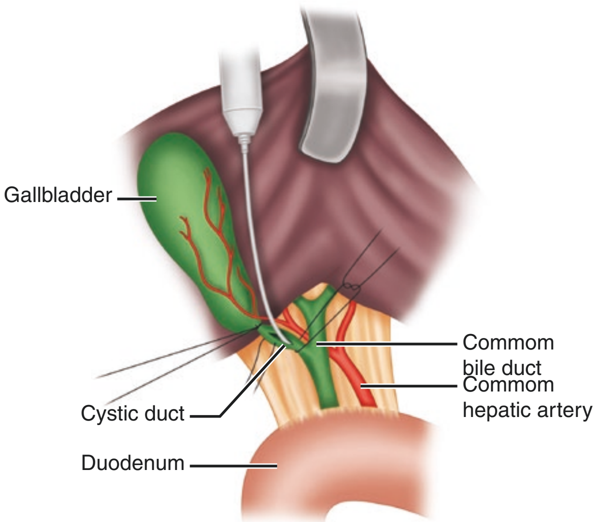


Fig. 14.22 Cystic duct is entered

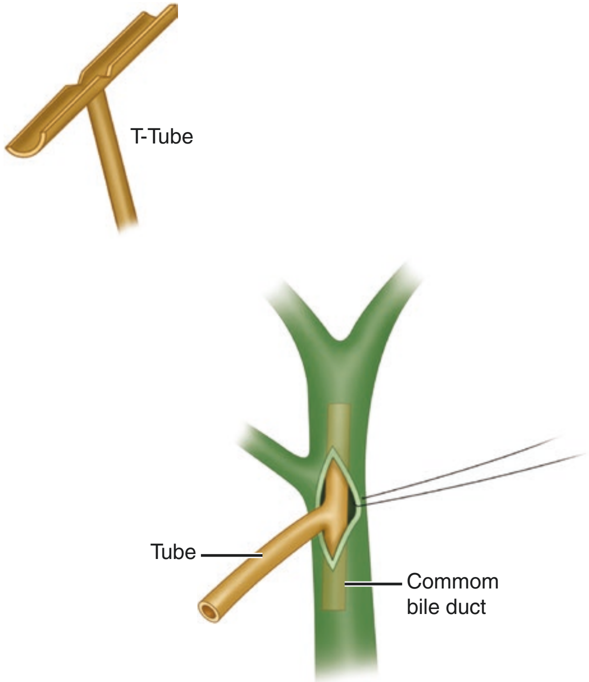


Fig. 14.23 T-tube drainage. Inset: T-tube

- **Step 3.** If there is no pathology, remove the catheter and doubly ligate the cystic duct. If choledocholithiasis or other pathology is found, proceed with common duct exploration. Occasionally, choledochoscopy is helpful.
- **Step 4.** T-tube draining is essential (Fig. 14.23).

Note

- If the common bile duct is not completely filled, the patient can be placed in a slight Trendelenburg position and 20 cm^3 of 30 percent Renografin used.

Common Bile Duct Exploration

- **Step 1.** Perform duodenal kocherization by careful incision of the lateral peritoneum and palpation of the duodenum, head of the pancreas, and distal common bile duct (Figs. 14.24 and 14.25).
- **Step 2.** Dissect tissue overlying the common bile duct no more than 1–2 cm distal to the cystic stump. Skeletonization of more than 2½ to 3 cm can result in ischemia to the duct.

Fig. 14.24 Dissecting the lateral peritoneum

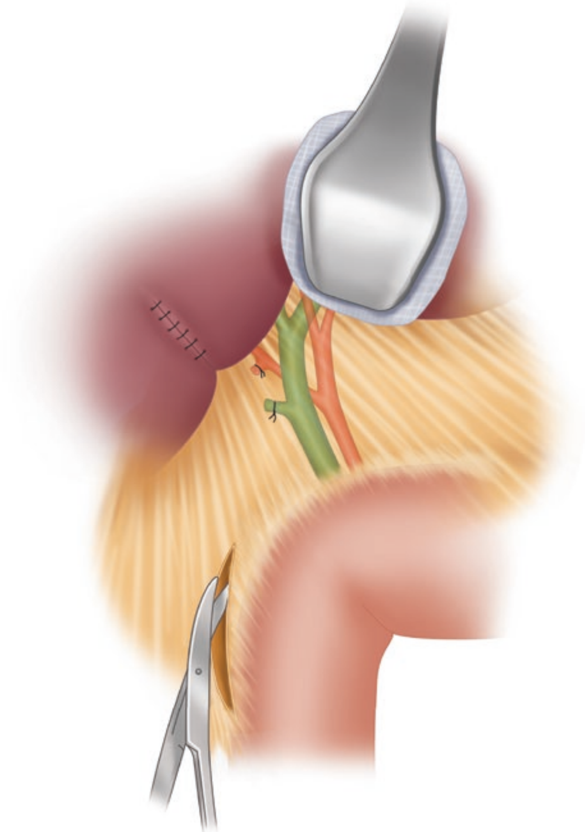
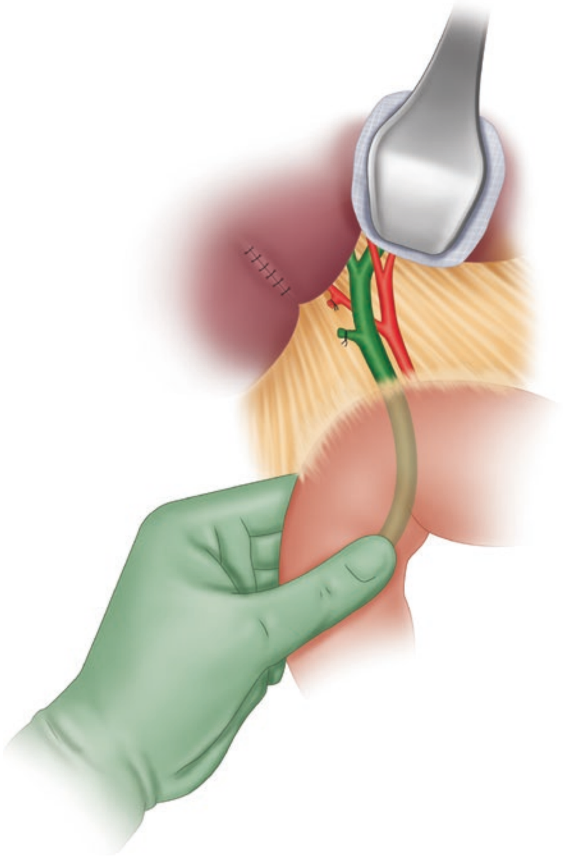


Fig. 14.25 Palpation



- **Step 3.** Place 4–0 Vicryl stay sutures medial and lateral to the cleaned common bile duct area. Aspirate the common bile duct to make sure you are in the right place. Incise the elevated anterior wall of the common bile duct to a length of 1 cm or less (Figs. 14.26, 14.27, 14.28, and 14.29).

Fig. 14.26 Stay sutures

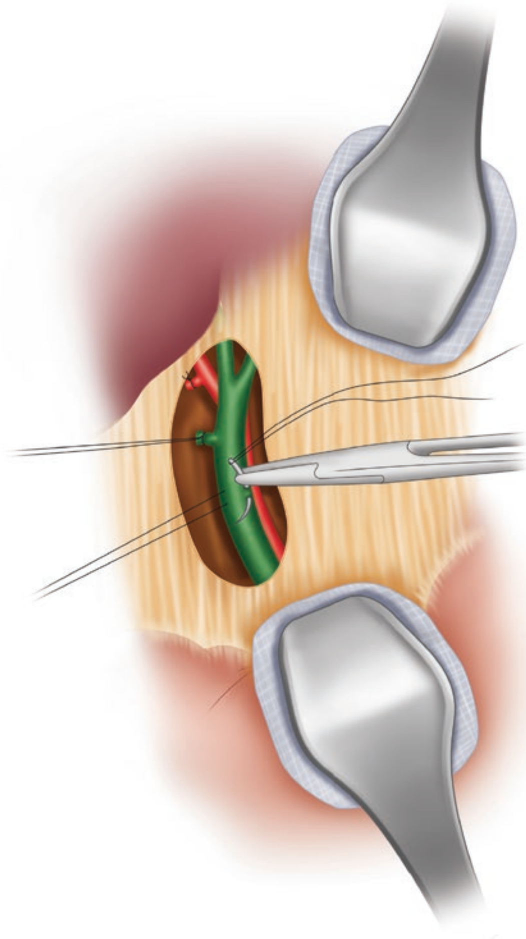
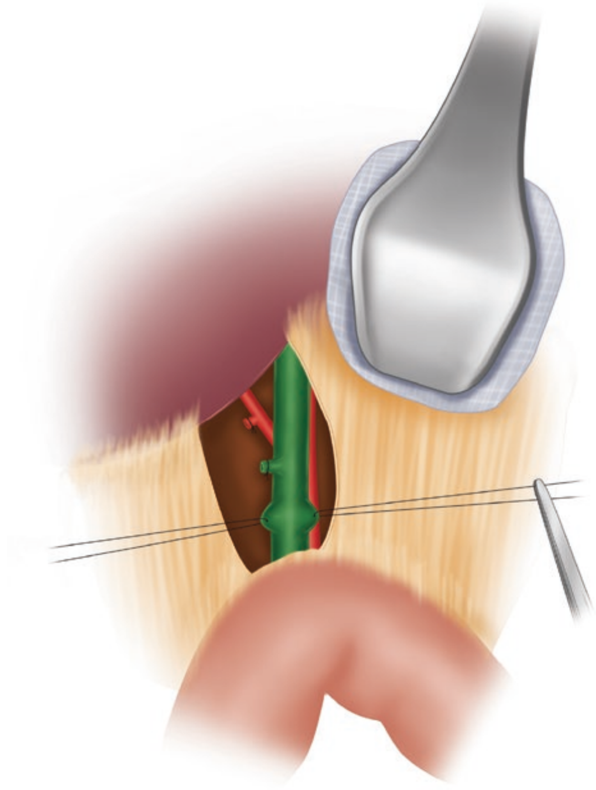


Fig. 14.27 Incision site



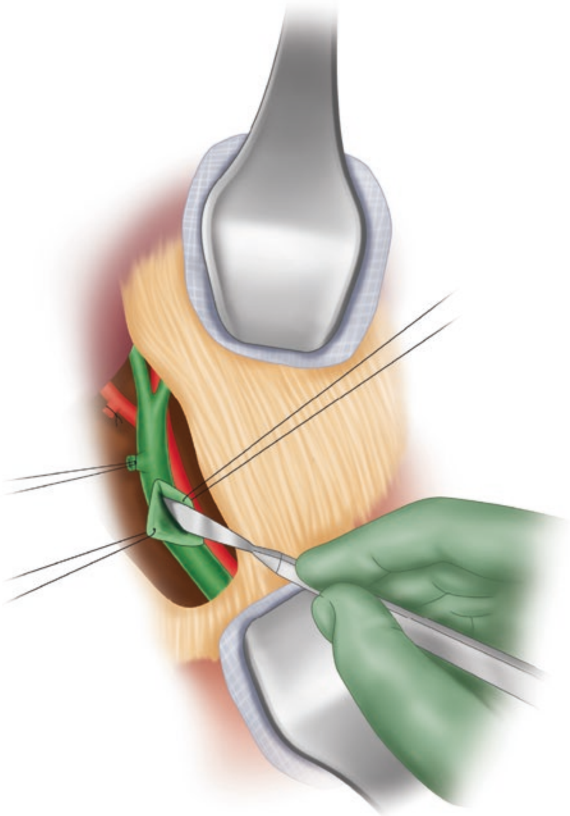


Fig. 14.28 Incision

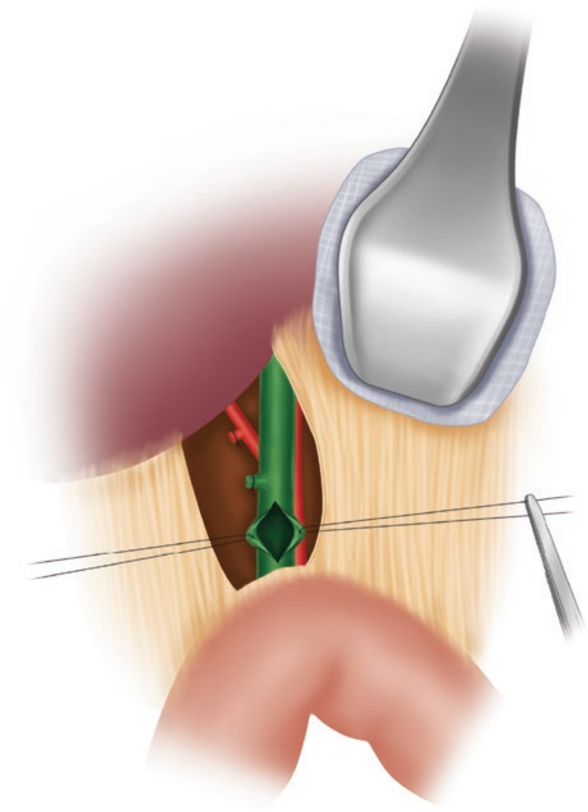


Fig. 14.29 Opening for stone removal

- **Step 4.** Remove stones by instrumentation (Randall stones forceps, scoops of several types and sizes, irrigation catheter, biliary Fogarty catheter) or extrinsic pressure by milking the stones to the upward choledochotomy (Figs. 14.30 and 14.31).

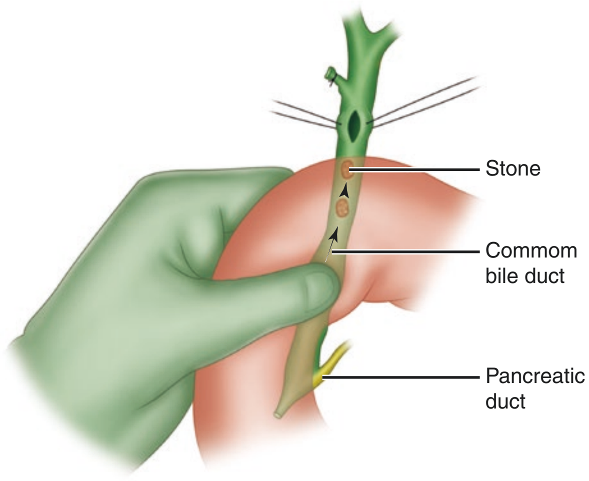


Fig. 14.30 "Milking" the stones

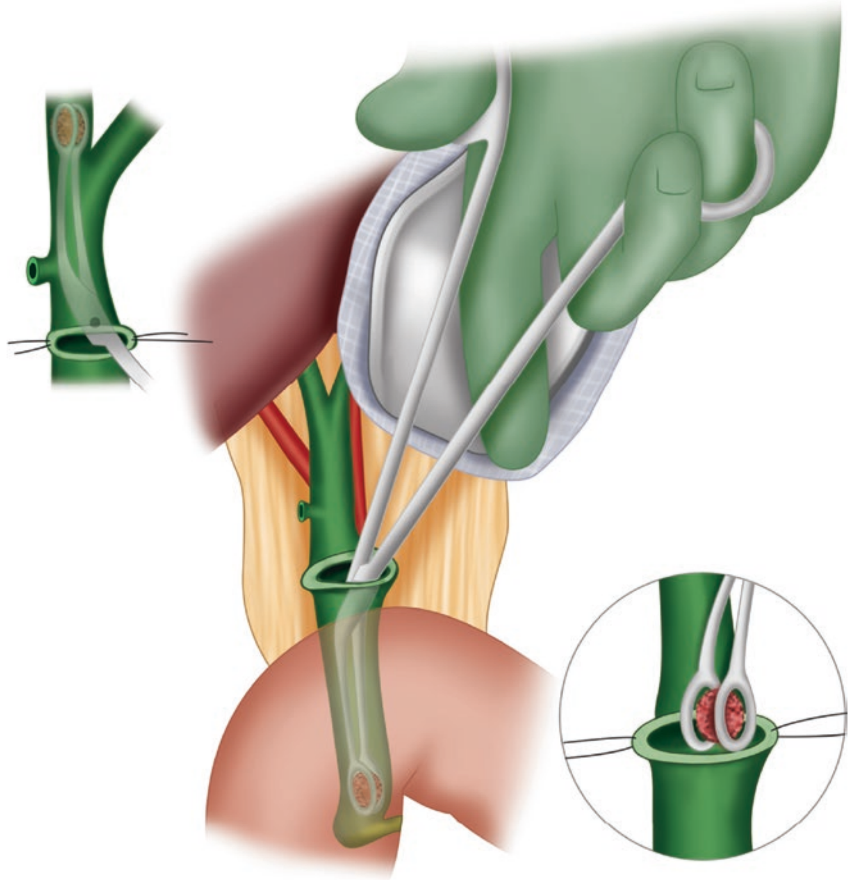
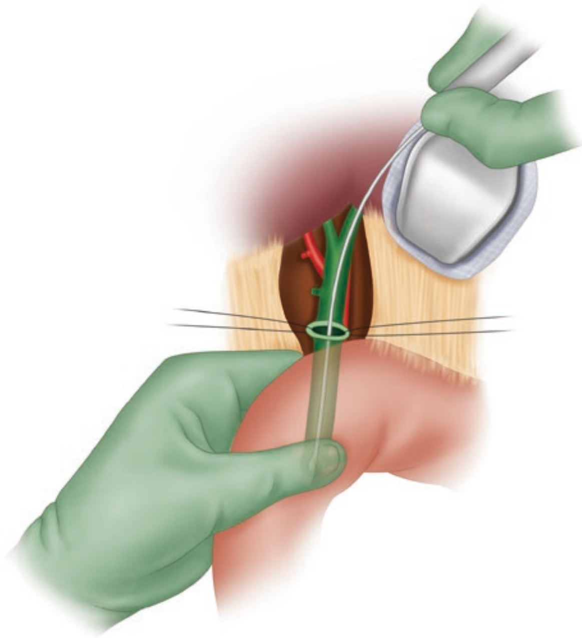


Fig. 14.31 Stones removed by instrumentation. Left inset: forceps grasps stone. Right inset: stone is extracted

Fig. 14.32
Demonstrating patency



- **Step 5.** Demonstrate ampullary patency using a small French catheter. If doubt about patency remains, use a Bakes No. 3 dilator very carefully to avoid false passage. Choledochoscopy may be helpful. Conduct repeated irrigation of the biliary ducts to remove small stones or sludge. If stones are impacted in the ampulla, papillotomy for their removal will be necessary (Figs. 14.32, 14.33, 14.34, and 14.35).

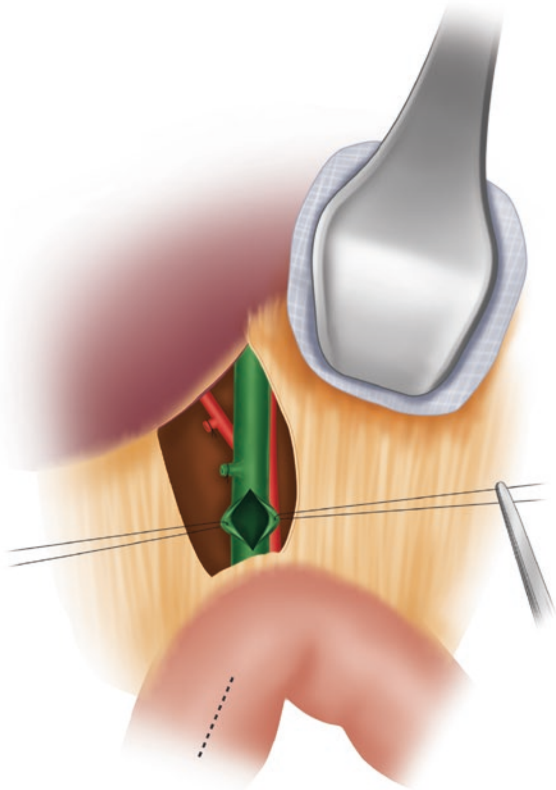


Fig. 14.33 Incision site for duodenotomy

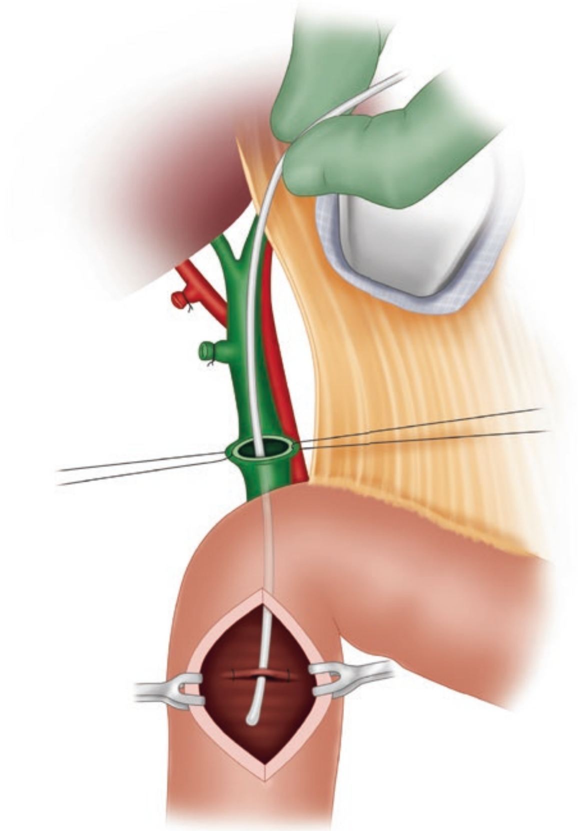
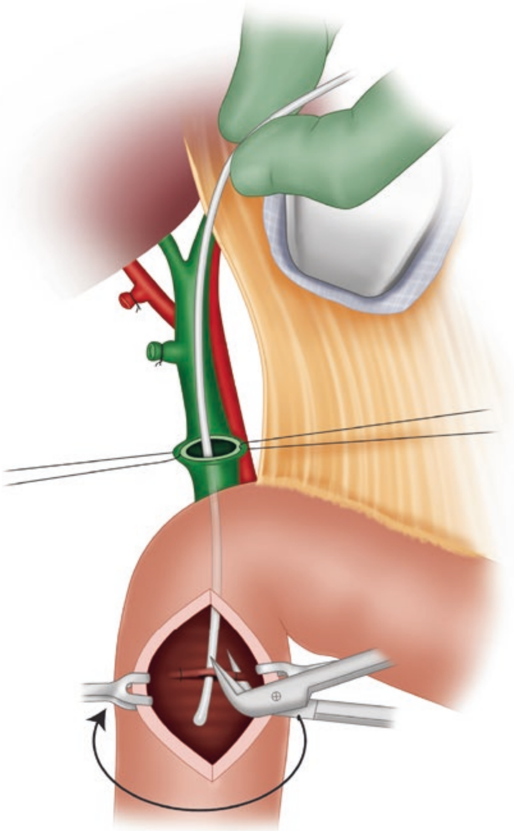


Fig. 14.34 Perform the duodenotomy only if it is necessary

Fig. 14.35 Papillotomy



- **Step 6.** Insert a T-tube and close the common bile duct with 4–0 interrupted Vicryl (Figs. 14.36 and 14.37).
- **Step 7.** Carry out T-tube cholangiography and bring T-tube straight out through the abdominal wall by a minute stab wound. Secure to skin with 2–0 silk.
- **Step 8.** Close abdominal wall.

Remember These Indications for Exploration of the Common Bile Duct

- Presence of a palpable stone in common bile duct.
- Failure of stone extraction by ERCP.
- Positive intraoperative cholangiogram.
- Jaundice in absence of ERCP.
- Cholangitis.
- When in doubt, explore! Exposure and mobilization of 2–5 cm in length may be obtained by mobilizing the distal common bile duct from the undersurface of the pancreas. Because the duct may be intrapancreatic (Fig. 14.6c), the pancreas and duodenum should be mobilized (Fig. 14.6b, d, e).

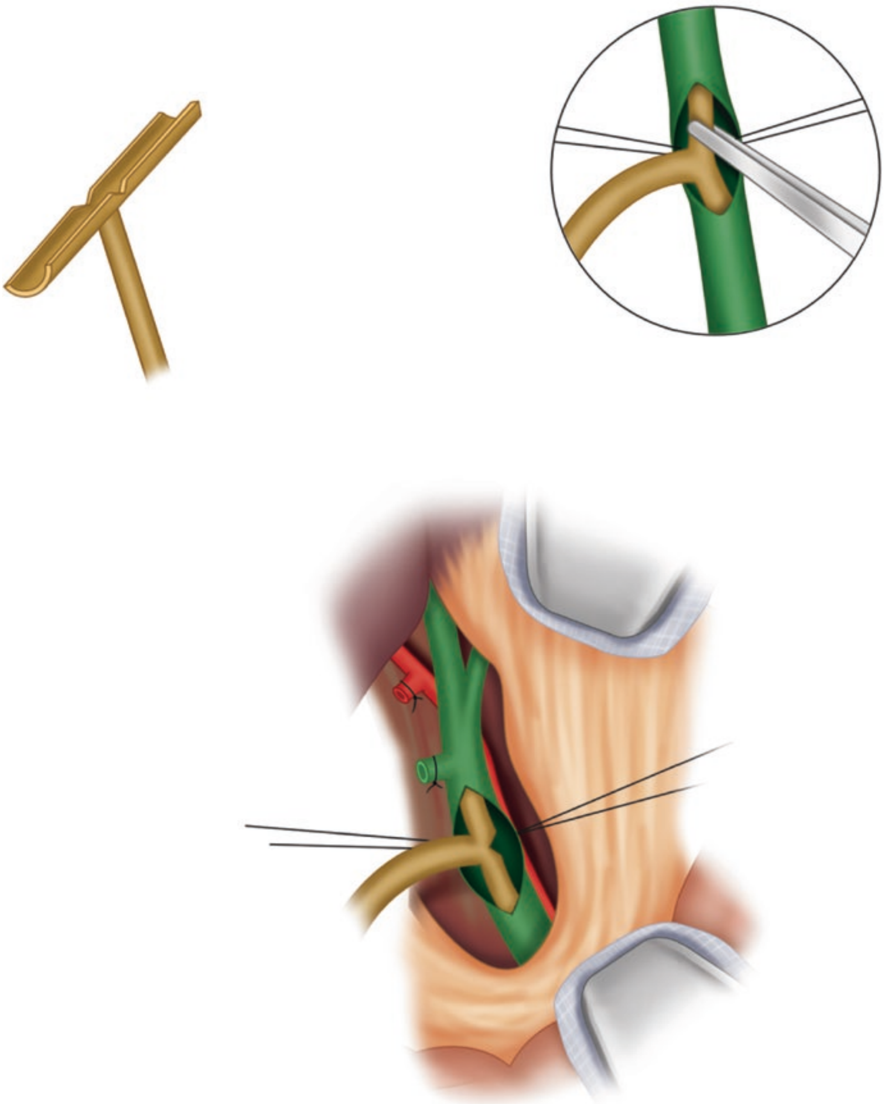
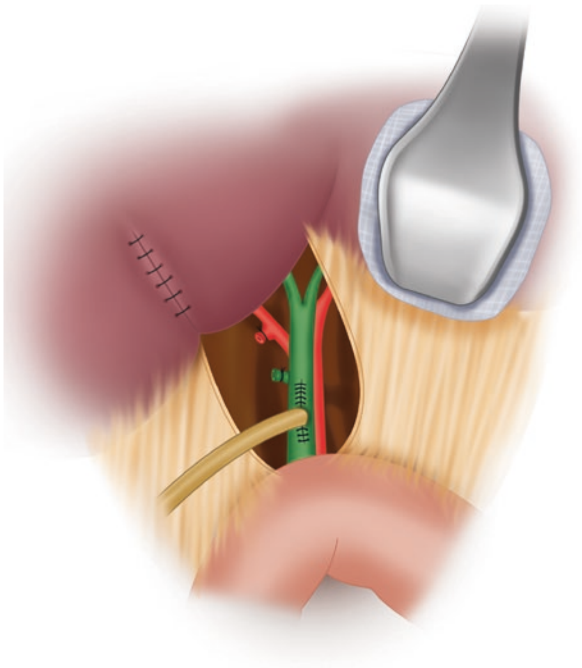


Fig. 14.36 Site of T-tube insertion

Fig. 14.37 Closure



Sphincteroplasty

- **Step 1.** Perform cholecystectomy and operating room cholangiogram.
- **Step 2.** Carry out duodenal kocherization (Fig. 14.38) and choledochotomy. Insert balloon catheter all the way down through the ampulla. Place stay sutures of 4–0 silk at the duodenal wall in the area of the palpable balloon. Perform duodenotomy using electrocautery (Fig. 14.39).

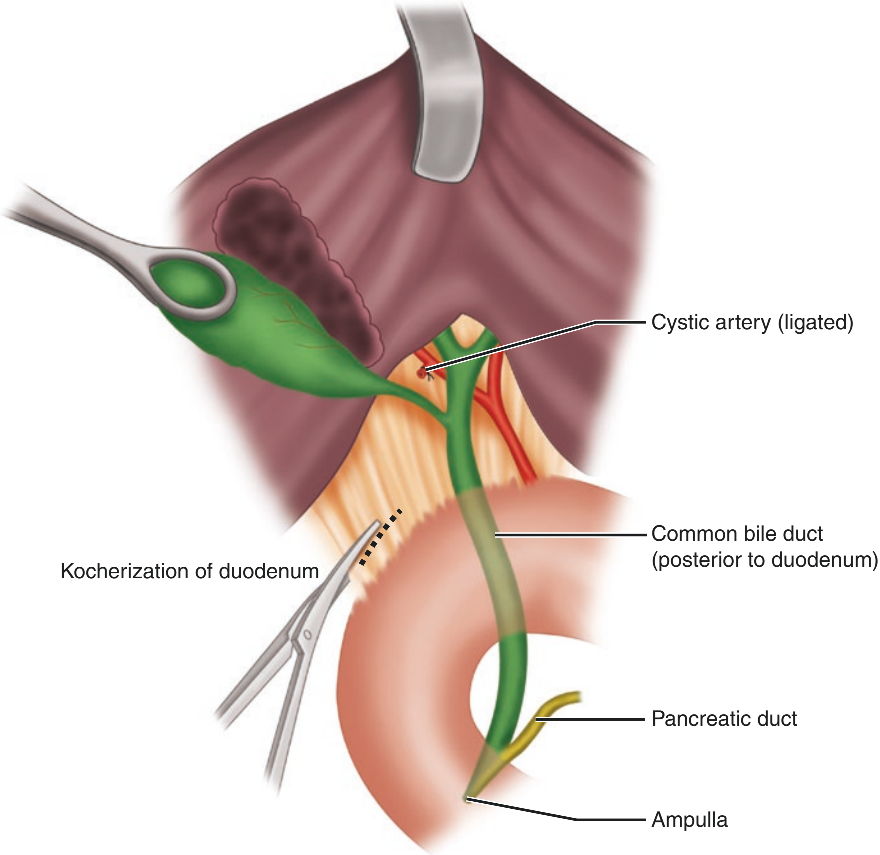


Fig. 14.38 Duodenal Kocherization

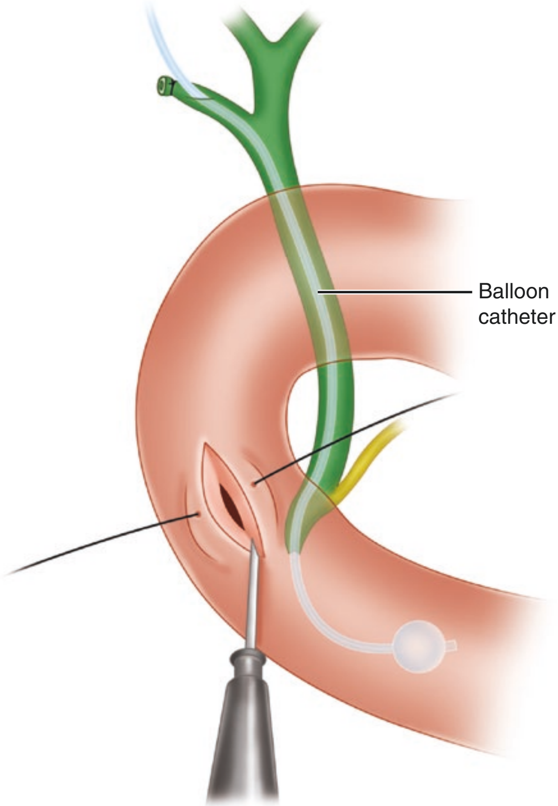


Fig. 14.39 Duodenotomy with electrocautery

- **Step 3.** Localize the ampulla.
- **Step 4.** At the 3 and 9 o'clock positions in the periampullary area, place 5–0 silk stay sutures (Fig. 14.40).

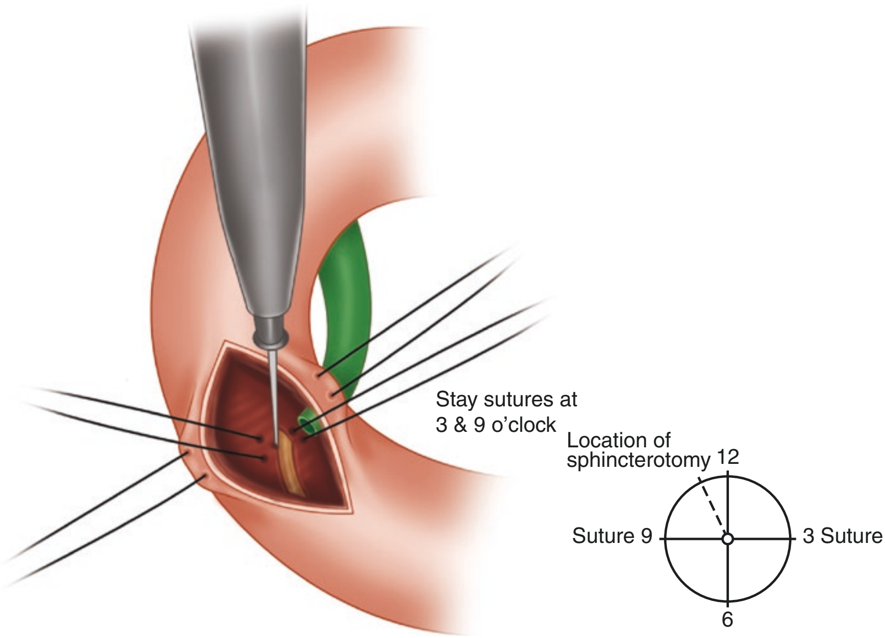


Fig. 14.40 Placement of stay sutures. Inset: schema

- **Step 5.** Perform a sphincterotomy between the 10 and 11 o'clock positions to a depth of 2–3 mm using electrocautery (Fig. 14.41).
- **Step 6.** Approximate the ductal and duodenal mucosa with interrupted 5–0 synthetic absorbable sutures (Figs. 14.41 and 14.42).

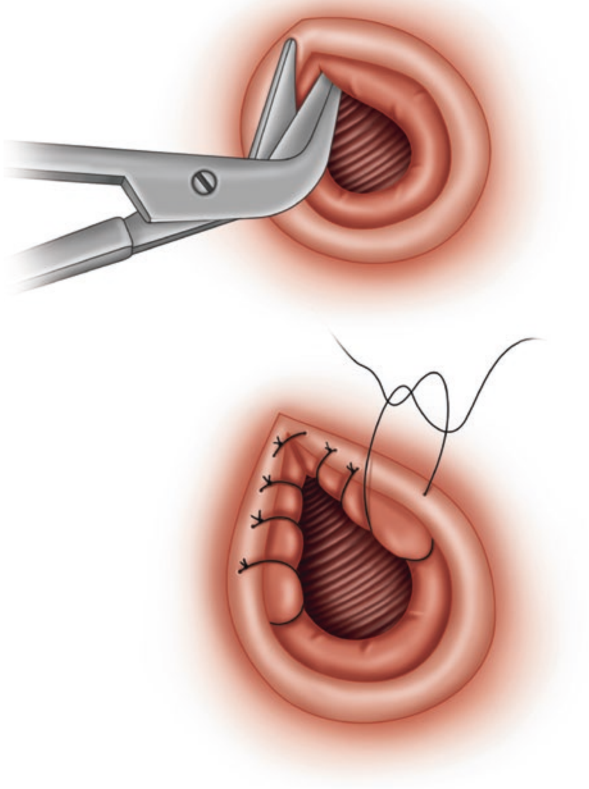
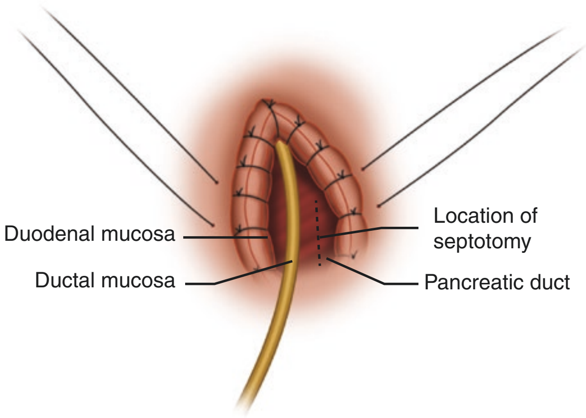


Fig. 14.41 Above: sphincterotomy. Below: mucosa is approximated

Fig. 14.42 Septotomy site



- **Step 7.** Localize the pancreatic duct opening, insert a probe, and carefully perform a septotomy to a depth of 2–4 mm by knife or Pott's scissors.

Note
- Wirsung's ductoplasty by interrupted sutures, as in step 6, is optional. If the ductal orifice is not found, secretin injection will be very helpful: one unit per kilogram of body weight.

- **Step 8.** Execute duodenorrhaphy in two layers. Place a T-tube into the common bile duct and insert a Jackson-Pratt drain (Fig. 14.43).

Choledochoduodenostomy

- **Step 1.** Establish good mobilization of the common bile duct and duodenum to avoid anastomotic tension. Anchor the duodenum to the common bile duct by placing a row of 4–0 Vicryl sutures posteriorly (Fig. 14.44).
- **Step 2.** Make a 1.5- to 2-cm transverse incision of the duodenum just below the suture line and a vertical or transverse incision of the common bile duct just above the suture line (Fig. 14.45).

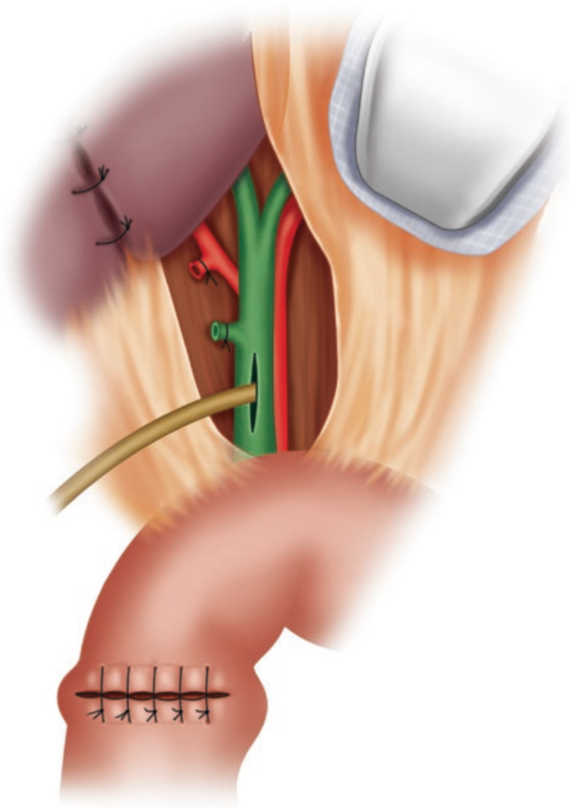


Fig. 14.43 Duodenorrhaphy. Drain and T-tube placed

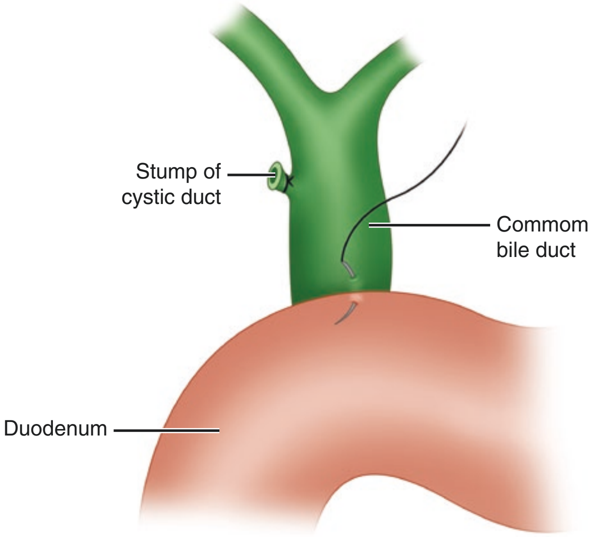


Fig. 14.44 Duodenum is anchored

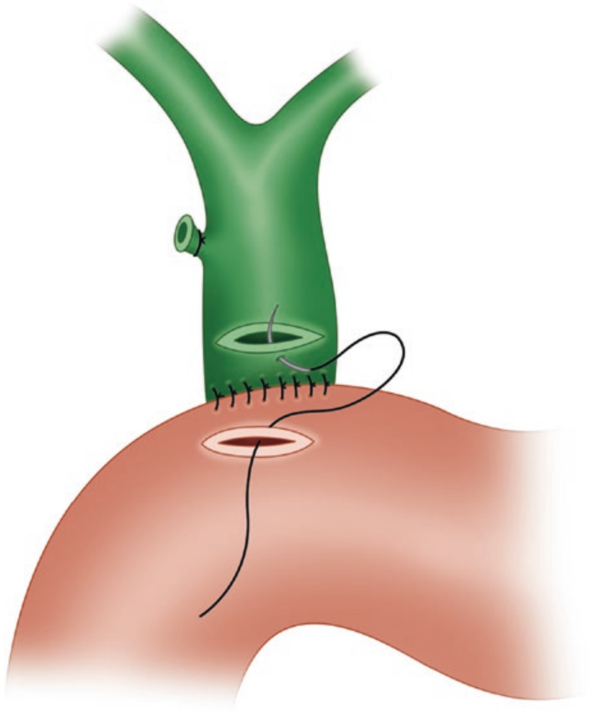


Fig. 14.45 Duodenum and common bile duct are incised

- **Step 3.** Perform the anastomosis in a single layer using interrupted 4–0 Vicryl sutures, full thickness, to the common bile duct and duodenum (Figs. 14.45, 14.46, and 14.47).

Note
- Alternatively, a side-to-side anastomosis can be performed.

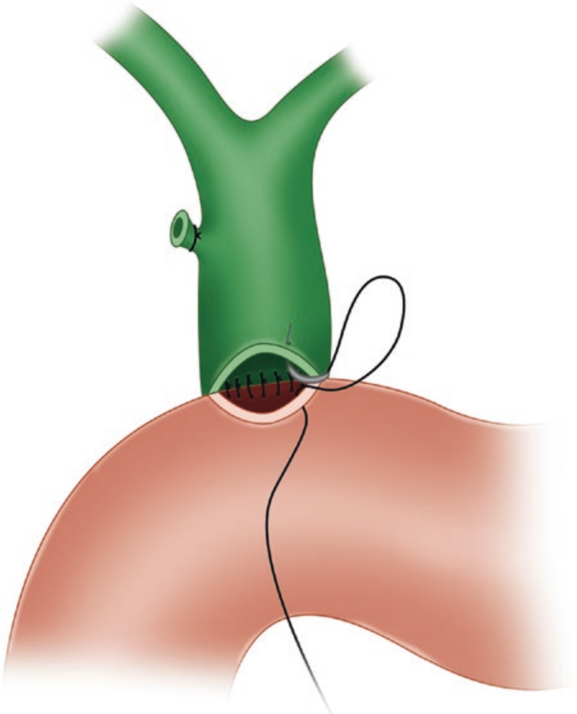


Fig. 14.46 Placement of sutures

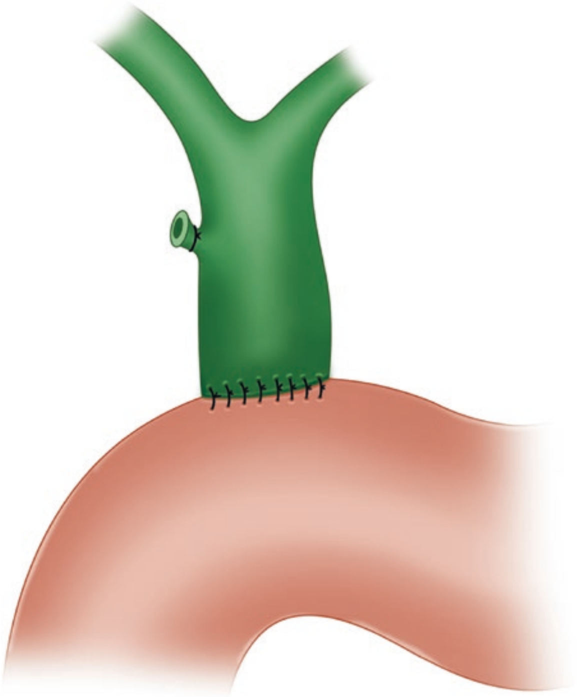


Fig. 14.47 Anastomosis of common bile duct and duodenum

Choledochocystectomy

- **Step 1.** Evaluate the extent of the cyst (Fig. 14.48).
- **Step 2.** Execute lysis of pericystic adhesions (Fig. 14.48).
- **Step 3.** Perform cholecystectomy and choledochocystectomy (Fig. 14.49).
- **Step 4.** Perform internal drainage by a 60-cm Roux-en-Y jejunal loop.
  (a) Jejunal interruption at approximately 60 cm using GIA.
  (b) Small opening in transverse mesocolon.
  (c) Distal jejunal Roux-en-Y loop up through the transverse mesocolon opening.
  (d) End-to-side hepaticojejunal anastomosis in one layer with interrupted 4–0 absorbable sutures (Fig. 14.50).
  (e) Secure the jejunum to the transverse mesocolon opening.

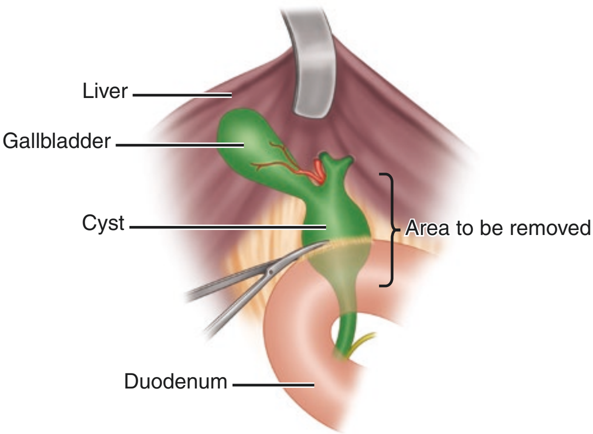


Fig. 14.48 Evaluation and lysis

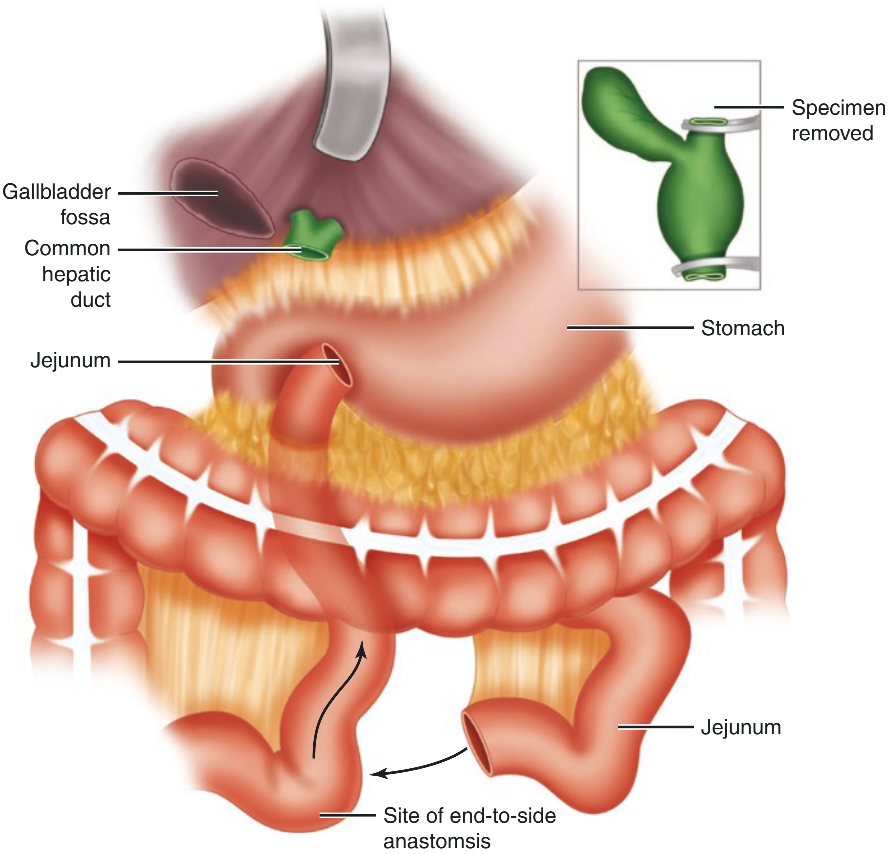


Fig. 14.49 Creation of Roux-en-Y. Inset: the specimen

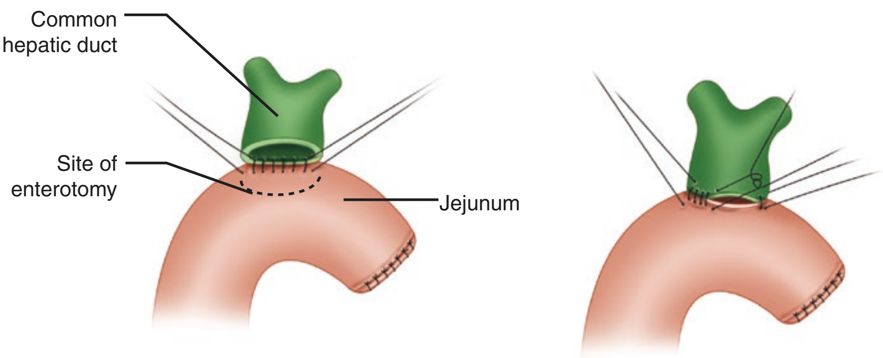


Fig. 14.50 Hepaticojejunal anastomosis

(f) End-to-side jejunojejunal anastomosis in two layers (Figs. 14.51 and 14.52).
(g) Be sure to secure the Roux-en-Y loop to the vicinity of the gallbladder fossa with two or three interrupted 3–0 silk sutures to avoid possible herniation as well as weight tension.
(h) If there is room, it is advisable to insert a T-tube into the common hepatic duct (Fig. 14.53).

- **Step 5.** Insert Jackson-Pratt drain and close abdominal wall.

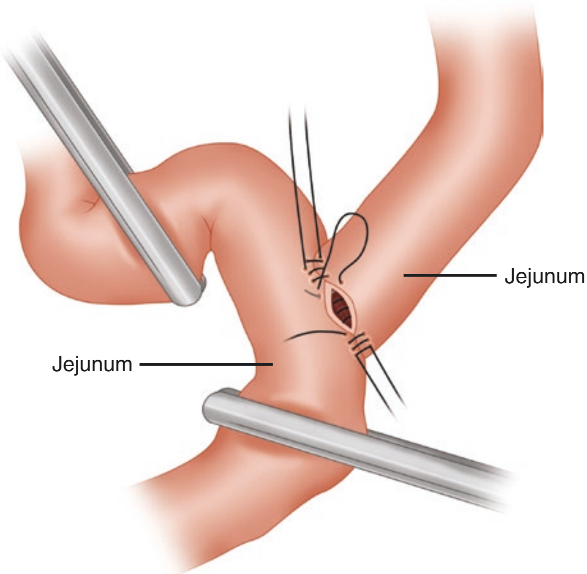


Fig. 14.51 Site of end-to-side jejunojejunal anastomosis

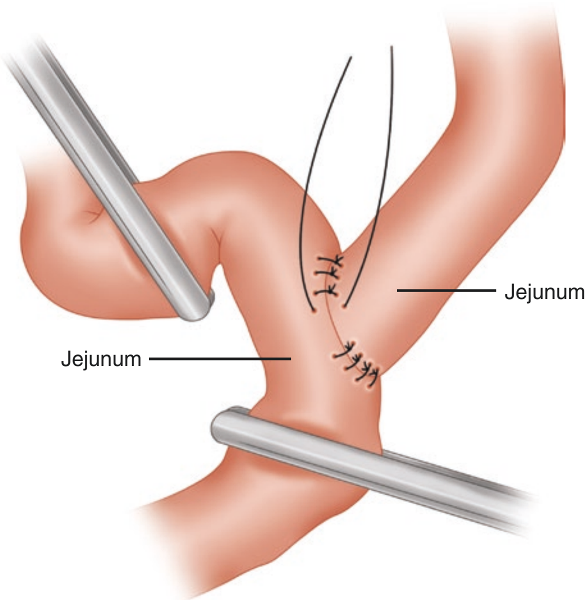


Fig. 14.52 Completed two-layer anastomosis

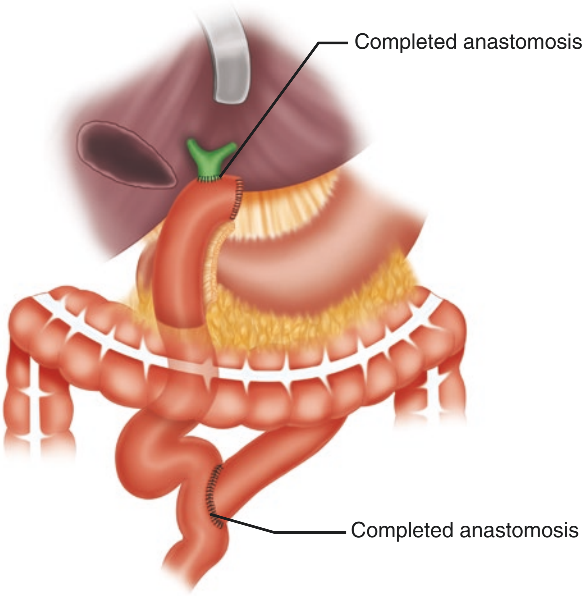


Fig. 14.53 The completed hepaticojejunostomy and jejunojejunostomy anastomosis

Hepp-Couinaud Procedure

The Hepp-Couinaud procedure is an alternative method for secondary repair of bile duct injuries. It allows the surgeon to avoid the inflamed lower CBD and utilizes virgin territory in the hilum for ease of anastomosis. This procedure is also extremely useful when sufficient proximal trunk is not available. Additionally, this procedure allows the surgeon to perform a long patent biliary-enteric anastomosis regardless of the caliber of the bile duct.

Preoperative preparation:

- Prior to incision, intravenous antibiotic of choice
  Anesthesia: General
  Position: Supine on a special X-ray operating room table
  Incision: Right subcostal or upper midline
- **Step 1.** The patient is placed in a position slightly slanted to the left decubitus. A long italic S-shaped subcostal incision provides wide and easy access to the region and allows for easy rotation of the liver.
- **Step 2.** The liver parenchyma is separated from the thickened capsule with a spatula or a surgical cotton ball. This zone bleeds little (some small venous elements) and hemostasis is easy, either by electrocoagulation or by hemostatic pads (Fig. 14.54).
- **Step 3.** Once the left hepatic duct has been exposed (Fig. 14.55), it may be incised to the right, the incision may extend to the anterior aspect of the convergence, or even onto the visible part of the right hepatic duct. To the left, the inci-

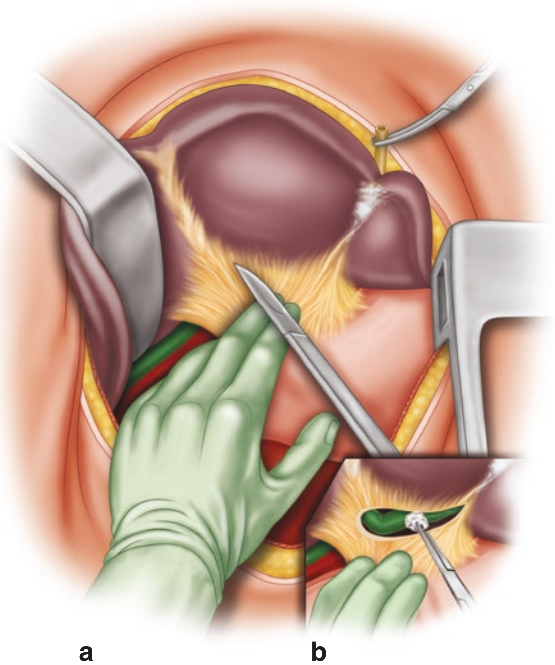
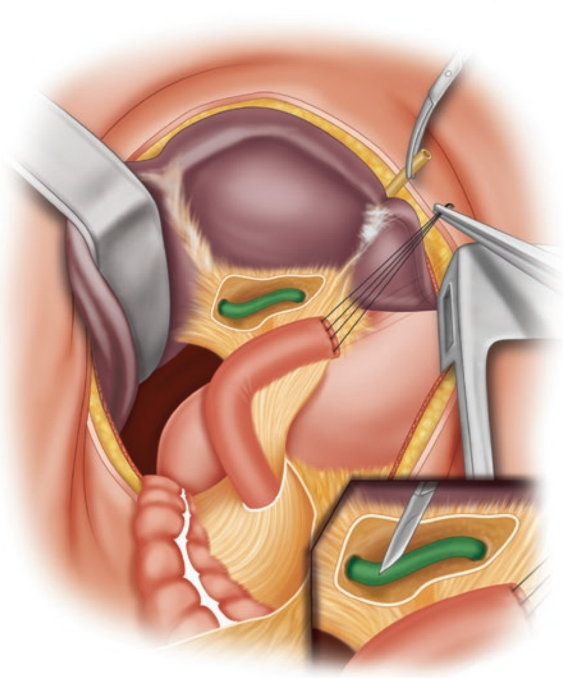


Fig. 14.54 (**a**) Glissonian capsule dissection off liver parenchyma. (**b**) Exposure of left hepatic duct. (Technique from Hepp J. Hepaticojejunostomy using the left biliary trunk for iatrogenic biliary lesions: the French connection. World J Surg. 1985;9:507–11)

Fig. 14.55 Exposure of left hepatic duct. (Technique from Hepp J. Hepaticojejunostomy using the left biliary trunk for iatrogenic biliary lesions: the French connection. World J Surg. 1985;9:507–11)



sion may be extended as needed in order to obtain an ideal minimum of 3 cm (Fig. 14.56).

One must remember that the arteries running to the left and quadrate lobes are superficial and close to the round ligament. They, of course, must be respected. This may be accomplished by separating them from the biliary wall and retracting them to the left.

- **Step 4.** Prior to anastomosis, the biliary tract must be cleared of all stones. Stones may be extracted in either duct by using either Dormia's probe or by washing them out. Fiber-optic endoscopy is usually impossible because of the small caliber of the ducts.
- **Step 5.** A 60-cm Roux loop, with the end closed, is then brought up retrocolically and an equivalently sized opening is made on its antimesenteric border.
- **Step 6.** From about 2 cm from the closed intestinal end, the jejunal loop is then opened on its free convex border for a distance equal to that of the intrahepatic duct incision.
- **Step 7.** The anastomosis is fashioned side-to-side with interrupted fine monofilament sutures. Six points are usually needed for each line of suture, the knots being tied on the inside for the posterior line, and on the outside for the anterior line (Fig. 14.57). Routine use of transanastomotic tubes is not recommended. If the apposition is imperfect or there is concern for anastomotic stricture a transient transanastomotic tube could be considered.

Fig. 14.56 Incision of left hepatic duct and jejunal loop. (Technique from Hepp J. Hepaticojejunostomy using the left biliary trunk for iatrogenic biliary lesions: the French connection. World J Surg. 1985;9:507–11)

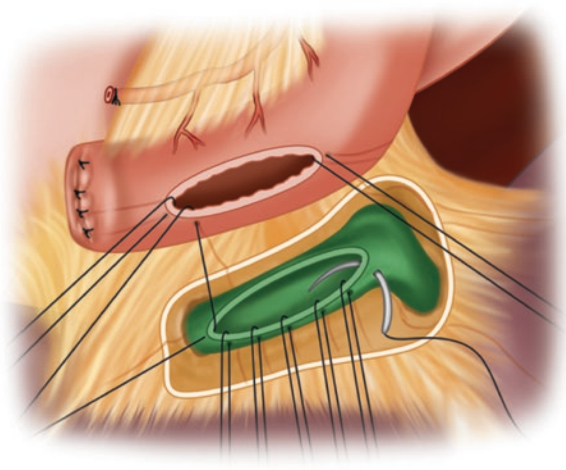


Fig. 14.57 Side-to-side anastomosis accomplished via interrupted monofilament sutures. (Technique from Hepp J. Hepaticojejunostomy using the left biliary trunk for iatrogenic biliary lesions: the French connection. World J Surg. 1985;9:507–11)

Anatomical Complications

- Vascular injury resulting in hemorrhage from the cystic artery, right hepatic artery, gastroduodenal artery veins in the gallbladder bed, inferior vena cava, and portal vein
- Ischemia from ligation of normal or aberrant right hepatic artery
- Overzealous skeletonization of common bile duct, supraduodenal artery, posterior pancreaticoduodenal artery
- Organ injury: injury to common bile duct, cystic duct, stomach, duodenum, pancreas, liver, and colon