Common Bile Duct Exploration: Surgical Legacy Technique

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Indications

Multiple alternatives have largely superseded open common bile duct (CBD) exploration. Endoscopic retrograde cholangiopancreatography (ERCP) with sphincterotomy provides access to the common duct for extraction of stones and biliary decompression. Laparoscopic transcystic common duct exploration or laparoscopic choledochotomy are alternatives when common duct stones are found at laparoscopic cholecystectomy. Open CBD exploration is still occasionally needed when these methods are not available or fail. The principles of access to the CBD described here are used during the performance of advanced biliary tract surgery and must be thoroughly understood.

Chills, fever, and jaundice prior to operation (in more than 90 % of cases CBD exploration reveals calculi)

Palpation of a calculus in the CBD

Acute suppurative cholangitis

Positive finding of a calculus on routine cystic duct cholangiography, preoperative ERCP, or percutaneous transhepatic cholangiogram

Access to the CBD is sometimes required during the course of other procedures in this region (e.g., to delineate the course of the CBD during a difficult ulcer operation). The principles delineated here apply in those situations as well. Adequate cholangiography can prove or disprove the presence of stones in many situations that formerly were listed as relative indications for CBD exploration.

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Preoperative Preparation

Computed tomography (CT) or sonography is used. Generally ERCP is performed as the next diagnostic maneuver when dilated ducts are seen, and intervention (papillotomy and stone extraction) may obviate the need for open CBD exploration.

Correct abnormalities of the serum prothrombin preoperatively with injections of vitamin K.

When CBD exploration is planned, the patient should receive perioperative intravenous antibiotics beginning 1 h prior to operation. To ensure an adequate antibacterial blood level, repeat the dose in 3 h, during the operation. We use either a third- or fourth-generation cephalosporin or a penicillin-aminoglycoside combination.

Pitfalls and Danger Points

Injuring the bile ducts

Creating a false passage into the duodenum when probing the CBD, damaging the ampulla or pancreas, inducing postoperative pancreatitis

Perforating a periampullary duodenal diverticulum

Sepsis

Failing to remove all of the biliary calculi

Operative Strategy

Avoiding Postoperative Pancreatitis

Postoperative acute pancreatitis can be lethal. Use routine cholangiography to minimize the number of unnecessary CBD explorations. Explore the distal duct with delicacy and meticulous care to avoid trauma to the ampulla or pancreas, which may induce pancreatitis.

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CBD Perforations

Another *serious and often fatal error* is to perforate the distal CBD and penetrate the pancreas with an instrument such as the metal Bakes dilator. When the surgeon experiences any difficulty negotiating the ampulla with an instrument, duodenotomy and direct exposure of the ampulla are preferable to repeated blunt trauma from above. Using a 10 F Coude or whistle-tipped rubber catheter, rather than a metal dilator, lessens the risk of ampullary trauma and postoperative acute pancreatitis. Never forcefully dilate the sphincter of Oddi; this procedure serves no useful purpose, and the trauma to the ampulla not only increases the risk of postoperative acute pancreatitis it produces lacerations and hematomas of the ampulla.

If an instrument has perforated the distal CBD and the head of the pancreas, it may be detected when the CBD is irrigated with saline by noting saline leakage from the posterior surface of the pancreas. The perforation may also be detected by cholangiography. This type of trauma, which leads to bile flow directly into the head of the pancreas, often causes fatal pancreatitis. For this reason, when this complication is identified, divide the CBD just above its entry into the pancreaticoduodenal sulcus; transfix the distal end of the duct with a suture and anastomose the proximal cut end of the CBD to a Roux-en-Y segment of jejunum. When this procedure is carried out, diverting the bile from the traumatized pancreas may prove lifesaving. Also insert a closed-suction drain behind the pancreatic head to remove any leaking pancreatic secretions.

If the CBD has been perforated at an accessible point proximal to the head of the pancreas, suture the laceration with 5-0 PG or PDS. If the laceration is not accessible, simply insert a large-caliber T-tube into the CBD for decompression proximal to the laceration. Then place a closed-suction catheter drain down to the region of the laceration.

Locating and Removing Biliary Calculi

To avoid overlooking biliary calculi, obtain a cystic duct cholangiogram before exploring the CBD. Be sure that the radiograph clearly shows the hepatic ducts and the distal CBD. If the hepatic ducts cannot be seen because the dye runs into the duodenum, administer morphine to induce spasm of the ampulla; alternatively, open the CBD, insert an 8 F Foley catheter into the proximal CBD, and use this device to obtain a radiograph of the intrahepatic radicles. This cholangiogram can provide an estimate of size, number, and location of calculi.

Always perform a Kocher maneuver before exploring the CBD. It permits the surgeon to place the fingers of the left hand behind the ampullary region with the thumb on top of the anterior wall of the duodenum. This allows the instrument to be directed more accurately while palpating its distal tip.

Once the CBD has been opened, the safest, most effective device for extracting stones is the pituitary scoop with a malleable handle. Available with various size cups, this device can be bent to the exact curvature required to pass through the CBD down to the ampulla. By delicate maneuvering, the surgeon can remove most stones with the scoop. Also, it is often easy to palpate a stone against this metallic instrument.

Other methods that are helpful for retrieving stones are the Randall stone forceps, the Fogarty balloon, and thorough saline irrigation. On rare occasions a Dormia basket can retrieve a stone that is otherwise inaccessible. Choledochoscopy, discussed below, is another excellent means for helping to identify residual biliary calculi in the operating room.

When the ampullary region contains an impacted stone that cannot be removed with minimal trauma by the usual methods, *do not hesitate to perform a sphincteroplasty for the purpose of extracting the stone* under direct vision. Otherwise, excessive trauma to the ampullary region may cause serious postoperative acute pancreatitis.

A completion cholangiogram through the T-tube after the exploration has been concluded is the final maneuver required to minimize the number of stones overlooked at operation. It is important to use a T-tube that is 16 F or larger following choledocholithotomy. Otherwise, the track remaining when the T-tube is removed may not be large enough to admit the instruments required to remove residual stones by Burhenne's method. Even small ducts admit a 16 F T-tube if the tube is trimmed by the technique described below in the section Insertion of the T-Tube.

Documentation Basics

- Cholecystectomy performed?
- Details of cholangiogram and findings
- Findings at exploration
- Size and type of T-tube placed, other drains

Operative Technique

Cholangiography

If for some reason the cystic duct is not a suitable route for cholangiography, insert a 21-gauge scalp vein needle into the CBD. Aspirate bile to confirm that the needle is in the duct lumen. Use a structure to fix the needle to the CBD. Attach a 2-m length of sterile plastic tubing filled with the proper

contrast medium. The remaining details of cholangiography are the same as those described in Chap. 77.

Kocher Maneuver

After the gallbladder has been removed and it is determined that CBD exploration is indicated, perform a Kocher maneuver (see Figs. 14.14, 14.15, and 14.16) by incising the lateral peritoneal attachments along the descending duodenum. Then incise the layer of avascular fibrous tissue that attaches the posterior duodenum to Gerota's fascia and to the foramen of Winslow. Elevate the duodenum and head of the pancreas by sharp and blunt dissection in the areolar plane until the inferior vena cava is seen. With the left index and middle fingers situated behind the pancreas and duodenum and the thumb applied to the anterior wall of the duodenum, palpate the distal CBD and the ampulla. Pay special attention to the ampullary region so as not to overlook a small ampullary carcinoma, which is often felt as a hard protrusion into the lumen from the back wall of the duodenum. An adequate Kocher maneuver allows the surgeon to palpate the distal duct and head of pancreas and makes it possible to straighten the distal duct by gentle downward traction.

Choledochotomy Incision

Incise the peritoneum overlying in CBD to identify the duct's anterior wall. Select an area for the choledochotomy preferably distal to the entrance of the cystic duct. Insert two guy sutures of 4-0 PG or PDS, one opposite the other on the anterior wall of the duct. If there are any obvious blood vessels located in this area, transfix them with 5-0 PG or PDS suture-ligatures or apply careful electrocautery. Use a No. 15 scalpel blade to make a short incision in the anterior wall of the CBD while the assistant holds up the guy sutures. Then use Potts angled scissors to enlarge the incision in both directions. Pay attention to the possibility that the cystic duct may share a wall with the CBD for a distance of 2 cm or more. If the incision is made in the vicinity of this common wall, it is possible to open the cystic duct instead of the CBD, which would cause considerable confusion. It is even possible to make an incision along the common wall and not encounter the lumen of either the cystic duct or the CBD and to expose the portal vein. If the anteromedial aspect of the CBD is used for the choledochotomy incision, this problem is avoided.

Exploring the CBD

As soon as the CBD has been opened, take a sample of the bile for bacteriologic culture and Gram stain. During passage of the instruments, maintain the left hand behind the duodenum and head of pancreas. Gentle downward traction can be used to straighten the distal duct, and the sense of touch facilitates passing the instruments through the ampulla.

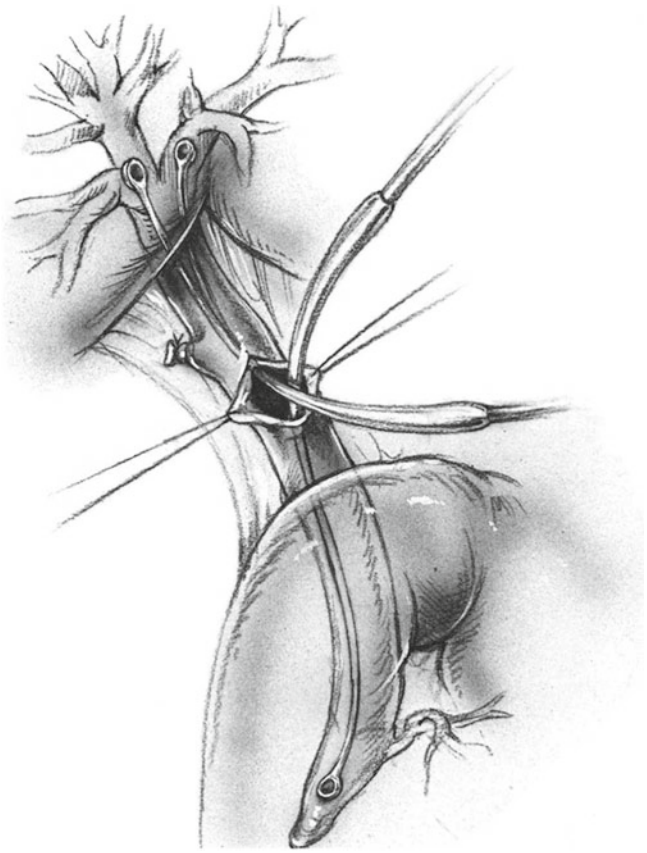

Fig. 80.1

Using the left thumb and index finger, milk down any possible stones from the common hepatic duct into the choledochotomy incision. Perform the same maneuver on the distal CBD. This maneuver often delivers several calculi into the choledochotomy. Take care not to push stones up into the intrahepatic biliary tree where subsequent extraction may be difficult.

Pass a pituitary scoop of the appropriate size up into the right and left main hepatic ducts to remove any possible calculi (Fig. 80.1). Then, with the left index finger placed behind the ampulla, use the right hand to pass a pituitary scoop down to the region of the ampulla and remove any calculi encountered with this maneuver. It is helpful simultaneously to palpate with the left index finger behind the distal CBD while the scoop is being passed. Avoid excessive trauma to the ampulla. A Randall stone forceps (Fig. 80.2) may be inserted into the CBD for the purpose of removing stones, but we have not found this instrument to be particularly valuable compared to the pituitary scoop. Following these maneuvers, use a small, straight catheter to irrigate

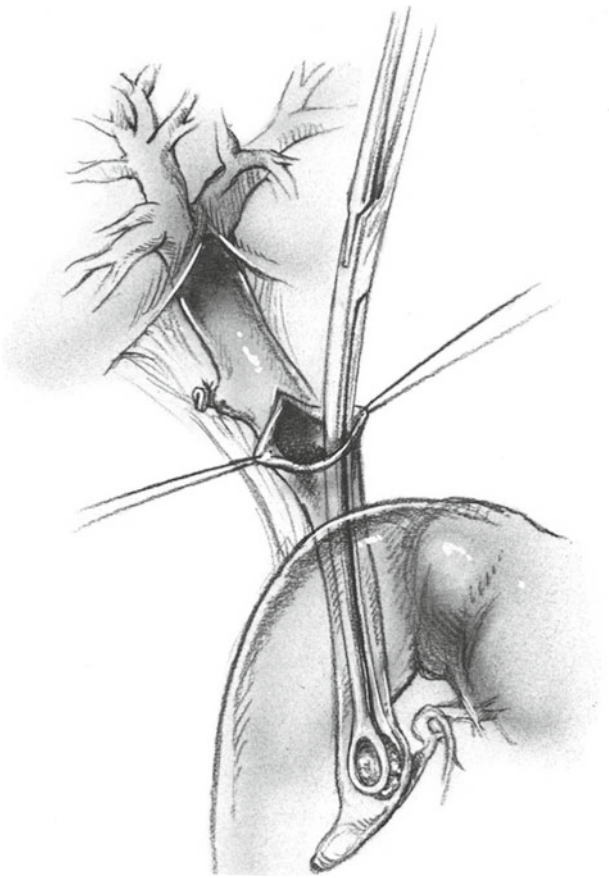

Fig. 80.2

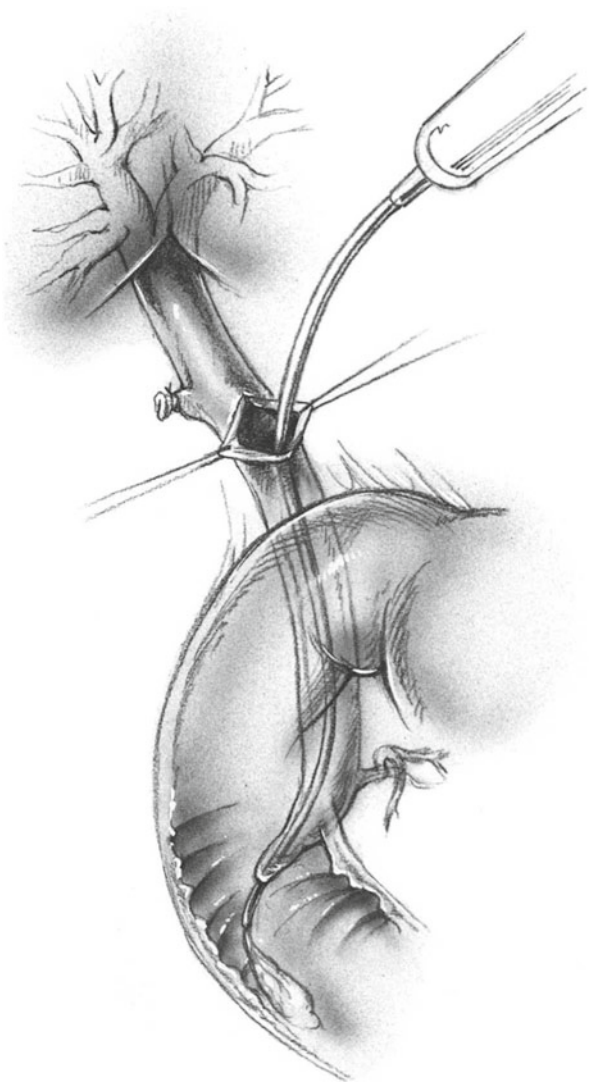

Fig. 80.3

both the hepatic ducts and the distal CBD with normal saline solution (Fig. 80.3).

Now try to pass a 10 F Coude tipped catheter through the ampulla. Inject saline through the catheter. The saline is seen to flow back out through the choledochotomy so long as the catheter is in the duct. When the catheter passes into the duodenum, the flow of saline ceases. If metal Bakes dilators are used instead to determine the patency of the ampulla, perform this maneuver with great delicacy as it is easy to perforate the distal CBD and to make a false passage through the head of the pancreas. It is not necessary to pass any instrument larger than a No. 3 Bakes dilator through the ampulla.

If there appears to be a calculus in the distal end of the CBD and it is not easily removed by means of the scoop, insert a biliary Fogarty catheter down the CBD into the duodenum. Blow up the balloon, which helps identify the ampulla by affording a sense of resistance as the catheter is pulled back. Gradually deflate the balloon as the catheter is withdrawn until it traverses the ampulla. As soon as the balloon is inside the CBD, reinflate and withdraw it. This occasionally removes a stone that has been overlooked. Repeat the same maneuver in the right and left hepatic ducts. It is for retrieval of hepatic duct stones that the Fogarty catheter has its greatest usefulness.

Another maneuver that occasionally removes a stone is use of a 16 F rubber catheter. Cut most of the flared proximal end of the catheter off and insert this end down the CBD to make contact with the stone. Amputate the tip of the catheter and attach a syringe to the catheter's distal tip; apply suction while simultaneously withdrawing the catheter. The suction sometimes traps the calculus in the end of the catheter, after which it is easily removed.

If an impacted stone in the distal CBD cannot be removed in a nontraumatic fashion by these various maneuvers, do not hesitate to perform a sphincteroplasty (see Chap. 82). This choice is safer than traumatizing the ampulla.

Choledochoscopy

We believe that choledochoscopy is an integral part of the CBD exploration. This procedure can detect and retrieve

stones or detect and biopsy ductal tumors, in some cases when all other methods have failed. Both rigid and flexible fiberoptic choledochoscopes are available. The rigid right-angle choledochoscope (Storz Endoscopy), which contains a Hopkins rod-lens system that is illuminated by a fiberoptic channel, gives the best image quality. It is simpler to operate and less expensive than the flexible fiberoptic endoscopes. If this scope is not available, a rigid nephroscope may be used instead.

Both rigid and flexible choledochoscopes must be sterilized by ethylene oxide gas, precluding repeated utilization of the same scope on the same day. Although flexible instruments have a higher initial cost, more expensive upkeep, shorter life span, much greater susceptibility to damage, and somewhat inferior optical properties, they have one important advantage over the rigid scopes: The flexible scope can be passed for greater distances up along the hepatic radicles for extraction of an otherwise inaccessible stone in this location. Similarly, the flexible scope can be passed right down to the ampulla and in about one-third of cases into the duodenum to rule out the presence of stones in the distal ampulla. Even if the scope does not enter the duodenum, when it is passed down to the ampullary orifice and the flow of saline enters the duodenum without refluxing back up into the CBD it constitutes good evidence that the distal duct is free of calculi. The rigid scopes are not generally of sufficient length to accomplish this mission. Another area in which the flexible scope is occasionally useful is extraction of retained calculi via the T-tube track subsequent to CBD exploration.

Because of their lower cost and greater durability, the rigid scopes have been adopted more widely than have the flexible scopes despite the handicap mentioned above. The horizontal arm of the Storz choledochoscope comes in two lengths: 40 and 60 mm. The vertical limbs of the two models are identical. The cross section of the horizontal limb, which must pass into the bile duct is 5 × 3 mm, approximately the diameter of a No. 5 Bakes dilator. If the CBD does not admit a No. 5 dilator, choledochoscopy by this technique is contraindicated.

Rigid and flexible choledochoscopes operate in a liquid medium, which requires that a continuous stream of sterile saline under pressure be injected into the sidearm of the scope. The saline then flows into the bile ducts. By crossing the two guy sutures over the choledochotomy incision, the CBD can be maintained in a state of distension by the flow of saline, providing optimal visualization. If the CBD is large enough, a metal instrument channel can be attached to the choledochoscope. Through this channel can be passed a flexible biopsy punch, a flexible forceps (7 F size), a Dormia stone basket, or a Fogarty biliary catheter (5 F caliber).

To use the choledochoscope, stand on the left side of the patient. Make the choledochotomy incision as far distal in the CBD as possible, and insert the choledochoscope toward

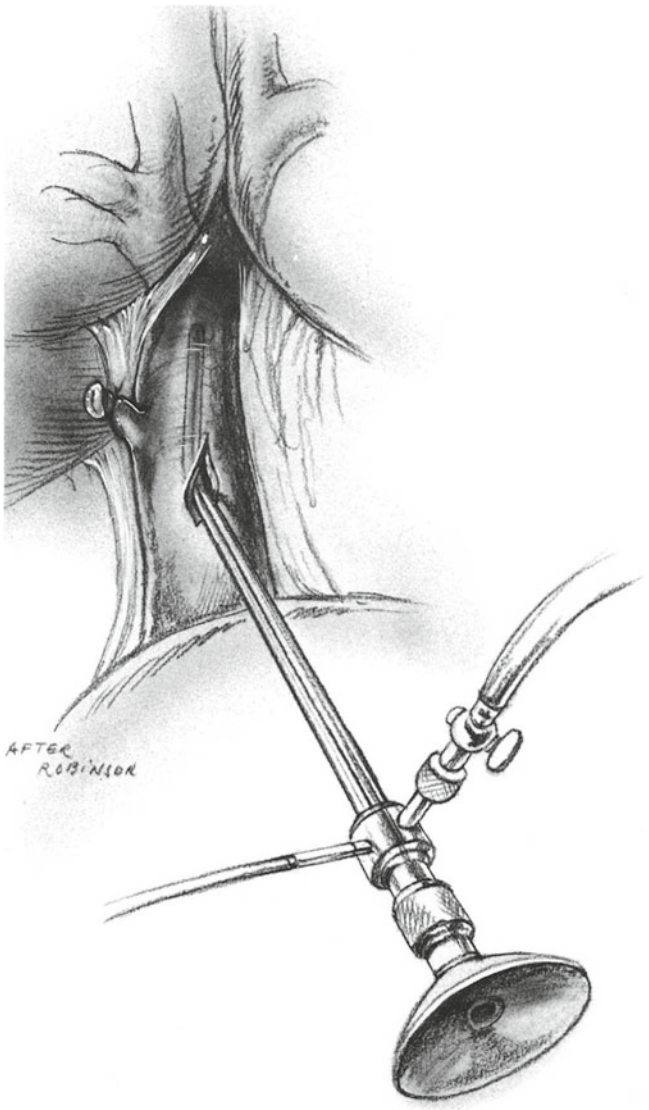

Fig. 80.4

the hepatic duct (Fig. 80.4). Initiate the flow of saline, and cross over the two guy sutures to reduce the loss of saline from the choledochotomy incision. Enclose the 1-l bag of sterile saline in a pressure pump (Fenwall) and use sterile intravenous tubing to connect the bag of saline to three-way stopcock. Insert the stopcock into the saline channel on the side of the choledochoscope.

Pass the horizontal limb of the scope up the common hepatic duct; the bifurcation of the right and left ducts is soon seen. Occasionally the first branch of the right main duct opens into the bifurcation so it resembles a trifurcation. Generally the left duct appears to be somewhat larger and easier to enter than the right. By properly directing the scope, it is possible to see into the orifices of many of the secondary and tertiary ducts. Withdraw the scope until the bifurcation is again seen and then pass the instrument into the right main duct using the same technique.

Before passing the scope down into the distal CBD, be sure the duodenum has been completely Kocherized. By placing slight traction with the left hand on the region of the ampulla, the surgeon helps elongate and straighten the course of the CBD. This step is important because the scope then visualizes the duct with clear focus to infinity. What the surgeon really wants to learn from the choledochoscopy is whether there are residual calculi between the scope and the ampulla. It requires exact knowledge of the appearance of the ampulla, which has been described as an inverted cone with a small orifice that opens and closes intermittently to permit the passage of saline. However, we have found that using these landmarks as the only criterion for identifying the ampulla may lead to error. Occasionally, this type of error permits a stone in the distal CBD to go undetected. Consequently, we believe there are only two positive methods for identifying the distal termination of the CBD. One is passage of the 60 mm choledochoscope through a patulous ampulla (rarely possible). When it is possible and if the duodenum is inflated with saline, one can see quite clearly the duodenal mucosa, which is markedly different from the smooth epithelium of the CBD. If the duodenum is not filled with saline, the mucosa is not seen. If the scope does not pass into the duodenum spontaneously, make no attempt to pass it forcibly. A second method for positively identifying the termination of the CBD is to pass a Fogarty balloon catheter alongside the choledochoscope into the duodenum. Inflate the balloon and draw back on the catheter. By following the catheter with a choledochoscope down to the region of the balloon one can be more certain that the entire CBD has been visualized and that there are no residual calculi.

Occasionally, the view of the distal CBD is impeded by what appear to be shreds of fibrin or ductal mucosa, which may hang as a partially obscuring curtain across the lumen of the duct. Despite some of these difficulties while interpreting choledochoscopic observations, this procedure does indeed detect stones that were missed by all other methods. In the hands of an experienced observer, choledochoscopy is probably the most accurate single method for detecting CBD stones. Calculi are easily identified. It may at first be confusing to find that a calculus 3 mm in diameter looks as big as a chunk of coal through the magnifying lens system. It is important to note that the Storz-type choledochoscope achieves a clear focus at distances of about 5 mm to infinity and that any object within 0–5 mm of the tip of the scope is not in focus.

If stones are seen, remove the choledochoscope and extract the stones by the usual means. If this is not possible, reinsert the choledochoscope and use a flexible alligator forceps, a Fogarty catheter, or the Dormia stone basket, *all under direct visual control of the choledochoscope*.

If a suspicious mucosal lesion is identified, insert a flexible biopsy punch and obtain a sample. Sometimes an ampullary or distal bile duct carcinoma is diagnosed in this manner. Bile duct cancers can be multicentric, and a second lesion may be found in the common duct or the hepatic duct. Under direct visual control, accurate biopsy is not difficult through the choledochoscope.

Routine CBD exploration and removal of calculi is accompanied by a 3 % incidence of retained stones. Choledochoscopy decreases the incidence of residual stones to 0–2 %. Using choledochoscopy routinely during CBD exploration adds no more than 10 min to the procedure and, in our experience, occasionally detects a stone that has been missed by all other modalities. Because it appears to be devoid of dangerous complications, we have adopted choledochoscopy as a part of routine CBD exploration. We have experienced one complication that was possibly related to the saline flush under pressure during choledochoscopy, namely, a mild case of postoperative pancreatitis. However, we have no data to indicate that the incidence of postoperative pancreatitis is increased by the use of choledochoscopy.

Sphincterotomy for Impacted Stones

Perform a complete Kocher maneuver down to the third part of the duodenum and insert a folded gauze pad behind the duodenum and the head of the pancreas. Pass a stiff catheter or a No. 4 Bakes dilator into the choledochotomy incision and down to the distal CBD. Do not pass it into the duodenum. By palpating the tip of the catheter or the Bakes instrument through the anterior wall of the duodenum, ascertain the location of the ampulla. Make a 4 cm incision in the lateral wall of the duodenum opposite the ampulla. Insert small Richardson retractors to expose the ampulla. Often the impacted stone is not in the lumen of the CBD but partially buried in the duct wall. This permits the Bakes dilator to pass beyond the stone and distend the ampulla. If this is the case, make a 10 mm incision with a scalpel through the anterior wall of the ampulla down to the metal instrument at 11 o'clock, a location far away from the entrance of the pancreatic duct. A 10 mm incision allows the dilator to enter the duodenum. Remove the Bakes dilator through the choledochotomy incision and explore the distal CBD through the sphincterotomy incision. Use the smallest size pituitary scoop. Often the stone can be easily removed in this fashion. If the papillotomy incision must be extended a significant distance to provide adequate exposure, a complete sphincteroplasty should be undertaken, which is described in Chap. 82. If the sphincterotomy is less than 10 mm in length, it is generally not necessary to suture the mucosa of the CBD to that of the duodenum. Rather, if there is no bleeding, leave the papillotomy undisturbed after the impacted stone has been removed. Repair the duodenotomy by the same technique as described following

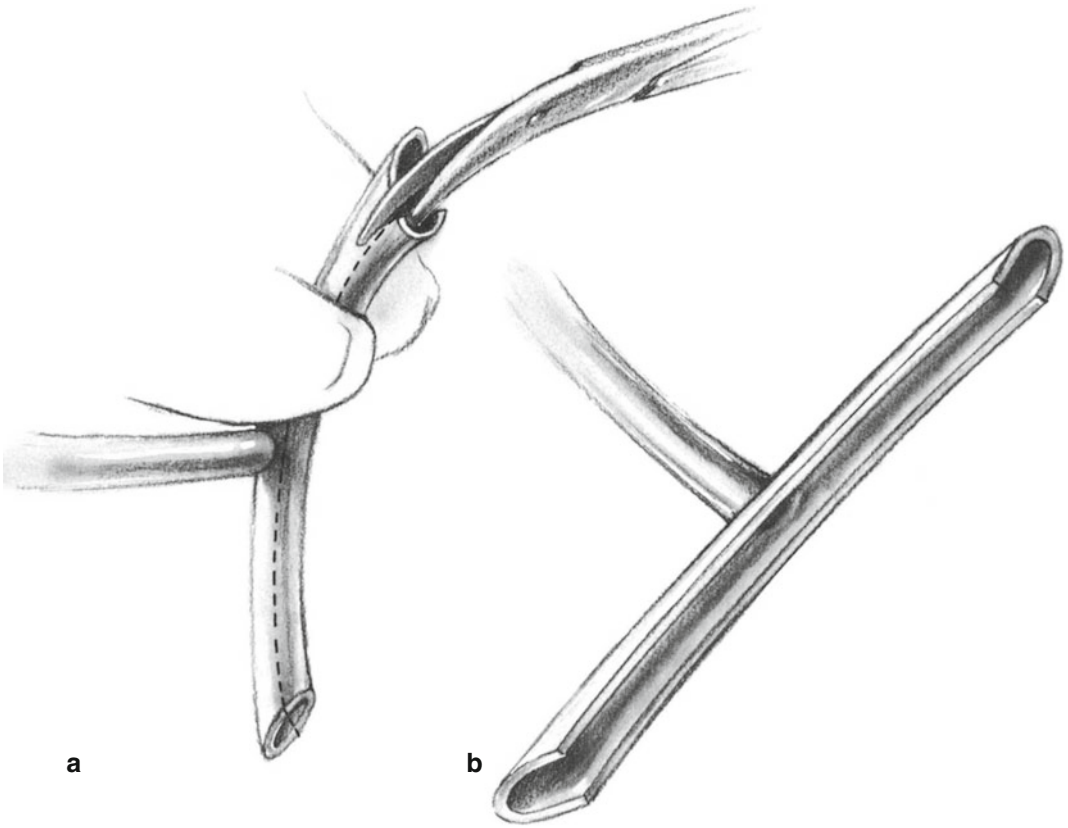

Fig. 80.5

sphincteroplasty (see Chap. 82). Then insert the T-tube into the CBD incision.

Checking for Ampullary Stenosis

Before completing the CBD exploration, the diameter of the ampulla of Vater may be calibrated by passing a catheter or a Bakes dilator. If a 10 F rubber catheter passes through the ampulla, no further calibration is necessary. If this device is too soft, try a Coude tipped catheter. If the catheters fail to pass, insert the left hand behind the region of the ampulla and pass a No. 3 Bakes dilator gently through the ampulla. Failure to pass through the ampulla with ease is more often due to pushing the instrument in the wrong direction than to an ampullary stenosis. In the absence of malignancy, we have found it rare to be unable to pass a catheter or dilator through the ampulla using gentle manipulation. If the preexploration cystic duct cholangiogram showed dye passing through the duodenum, failing to pass a 3 mm instrument through the ampulla is not by itself an indication for sphincteroplasty or biliary-intestinal bypass.

In any case, never use excessive force when passing these instruments. Penetration of the intrapancreatic portion of the CBD may produce fatal complications, especially if the damage is not recognized during the operation.

Insertion of the T-Tube

Although it is possible in some cases to avoid draining the CBD following stone removal, we believe that a T-tube should be inserted routinely to decompress the CBD and to facilitate cholangiography 7–8 days following surgery. Do not use a silicone T-tube, as this substance is nonreactive. Consequently, there may be no well-organized tract from the CBD to the outside, and bile peritonitis may occur when the silicone tube is removed. Use a 16 F rubber tube to facilitate extraction of any residual stones postoperatively through the T-tube track. If the duct is small, excise half the circumference from the horizontal limb of the 16 F tube as illustrated in Fig. 80.5a, b. After inserting the T-tube, close the choledochotomy incision with a continuous 4-0 atraumatic PG or PDS suture (Fig. 80.6). Make this closure snug around the T-tube to avoid leakage during cholangiography and subsequent leakage of bile.

Completion Cholangiogram

Eliminate the air in the long limb of the T-tube by inserting the long cholangiogram catheter that was used for the cystic duct cholangiogram down into the vertical limb of the T-tube for its full distance. Then gradually inject the contrast

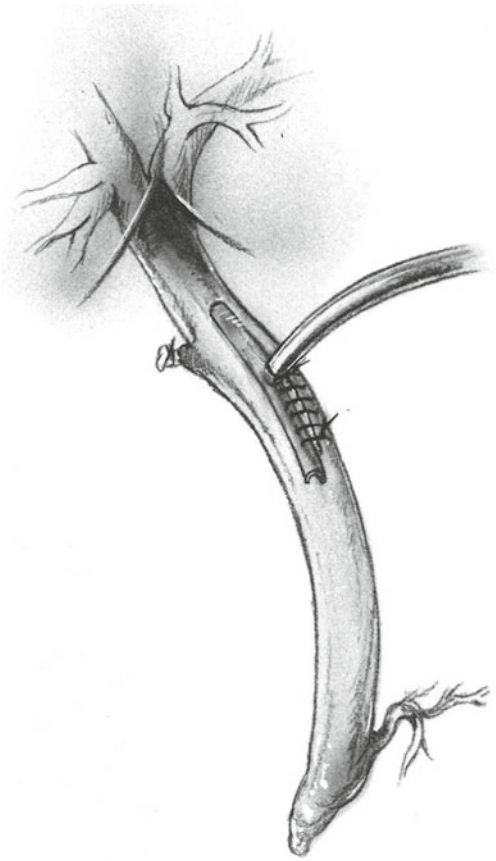

Fig. 80.6

medium into this limb while simultaneously removing the plastic catheter. This maneuver fills the vertical limb with contrast material and displaces the air. Then attach the T-tube directly to a long plastic connecting tube, which in turn is attached to a 30 ml syringe.

Elevate the left flank about 10 cm above the horizontal operating table. Stand behind a lead screen covered with sterile sheets and obtain the cholangiogram by injecting 4 ml of diluted contrast medium for the first radiograph and an equal amount for the second and third pictures. Fluoroscopy with a C-arm (if available) allows the surgeon to watch the flow of contrast and facilitates the procedure. We use a mixture of one part water-soluble contrast and one or two parts saline. The larger the duct, the more dilute is the solution to avoid obscuring small stones within a dense column of dye.

If the contrast material has not entered the duodenum, repeat the sequence after giving nitroglycerin intravenously. If the contrast material still does not enter the duodenum but the radiograph is otherwise negative, discontinue the study. Severe sphincter spasm often follows ampullary instrumentation and cannot be overcome during completion cholangiography.

Drainage and Closure

Bring the T-tube out through a stab wound near the anterior axillary line. Place a closed-suction drain through a separate stab wound and bring it down near the CBD. Place omentum over the CBD and under the incision. Suture the T-tube to the skin, leaving enough slack between the CBD and the abdominal wall to allow for some abdominal distension. Close the abdominal wall in the usual fashion.

Postoperative Care

Attach the T-tube to a sterile plastic bag. Permit it to drain freely by gravity until cholangiography is performed through the T-tube in the radiology department on postoperative day 5. Do not permit contrast material to be injected into the T-tube under pressure, as it may produce pancreatitis or bacteremia. Injection by gravity flow is preferable. If the cholangiogram is negative and shows free flow into the duodenum, clamp the T-tube. Unclamp it if the patient experiences any abdominal pain, nausea, vomiting, shoulder pain, or leakage of bile around the T-tube. Remove the T-tube on postoperative day 21.

Following choledocholithotomy, continue antibiotics for at least 3 days, depending on the results of the Gram stain, the bacteriologic studies, and the patient's clinical response. Continue nasogastric suction for 1–3 days. Remove the closed-suction drain 4–7 days following surgery unless there has been significant bilious drainage.

Observe the patient carefully for possible development of postoperative acute pancreatitis by determining the serum amylase levels every 3 days. If there is significant elevation, continue nasogastric suction and intravenous fluids. Some patients with postoperative acute pancreatitis do not have pain or significantly elevated serum amylase, but they do have intolerance for food, with frequent vomiting after nasogastric suction has been discontinued. In these cases a sonogram or CT scan showing an enlarged pancreas is enough to confirm the diagnosis. In general, do not feed the patient following biliary tract surgery if the serum amylase level is significantly elevated or if there is any other strong suspicion of acute pancreatitis, as this complication may be serious.

Complications

Bile Leak and Bile Peritonitis

T-Tube Displacement. The T-tube is fixed at two points: (1) the CBD and (2) the point on the skin where the T-tube is sutured in position. Enough slack must be left in the long limb of the T-tube between the CBD and the skin so an

increase in abdominal distension does not result in the tube being drawn out of the CBD. Occasionally, the T-tube is inadvertently partially withdrawn from the CBD even before the abdominal incision is closed. When bile leaks around the choledochotomy incision, bilious drainage from the drain track alongside the T-tube is noted. If this leak occurs during the first few days following the operation, upper abdominal pain and tenderness may appear, indicating bile peritonitis. A localized bile leak is fairly well tolerated in the postoperative patient who has adequate drainage, whereas when bile spreads diffusely over a large part of the abdominal cavity it may produce generalized bile peritonitis if the bile is infected. Diffuse abdominal tenderness generally demands either immediate laparotomy for replacement of the T-tube or insertion of an ERCP stent into the CBD.

Ductal Injury. When a completion cholangiogram through the T-tube is obtained in the operating room, a *major* ductal injury is apparent on the film, whereas an injury to an *accessory* duct may not be. If the latter manifests by continuous drainage of small to moderate amounts of bile along the drain tract and the cholangiogram is persistently normal, remove the T-tube and insert a small Foley catheter into the drain tract. Two weeks after surgery, perform cholangiography through this catheter after the balloon has been inflated. The most frequently injured anomalous bile duct is that which drains the dorsal caudal segment of the right lobe.

Postoperative Acute Pancreatitis

Acute pancreatitis following choledocholithotomy accounts for about half the postoperative fatalities. It is often caused by instrumental trauma to the ampullary region owing to excessive zeal when dilating the ampulla or when extracting an impacted stone. In the latter case, if the impacted stone cannot be removed with ease through the choledochotomy incision, approach it via a duodenotomy and papillotomy. Treatment of acute pancreatitis calls for prolonged nasogastric suction, fluid replacement, and respiratory support when indicated. Antibiotics are probably also indicated.

Frequent determinations of the serum amylase level in patients following choledocholithotomy are necessary because some patients with postoperative pancreatitis do not complain of an unusual degree of pain. Their only symptom may be abdominal distension and vomiting unless shock and hypoxia supervene. The mortality rate following postoperative acute pancreatitis is reported to be quite high, approaching 30–50 %. Total parenteral nutrition is indicated because many of these patients require 3–6 weeks of nasogastric suction before the amylase returns to normal, at which time food may be given by mouth. Premature feeding in these cases may cause a severe, even fatal exacerbation.

Increasing Jaundice

After choledocholithotomy in the jaundiced patient, it is common for the serum bilirubin concentration to increase by 4–6 mg/dl during the first postoperative week. This does not mean that the patient necessarily has a CBD obstruction. Rather, imposition of major surgery and anesthesia on the liver already damaged by a period of ductal obstruction temporarily aggravates the hepatic dysfunction. By postoperative days 10–12, the bilirubin level has peaked and has started on its way down toward normal, unless there is another cause for the postoperative jaundice, possibly a blood clot or an overlooked carcinoma in the main hepatic duct. Obstruction of the distal CBD by a retained stone does not produce postoperative jaundice if the T-tube is functioning properly. Obtain a routine cholangiogram through the T-tube by postoperative day 7. It can clarify the cause of the persistent jaundice.

Hemorrhage

Intraabdominal Hemorrhage. Intraabdominal hemorrhage often manifests as red blood coming through the drainage track. If it is not accompanied by systemic symptoms or abdominal signs, one may suspect that the bleeding arises from a blood vessel in the skin or the abdominal wound. Bleeding of sufficient magnitude to require one or more blood transfusions invariably originates from the operative area. The cause may be a defective ligature on the cystic artery or oozing from the liver or some intraabdominal blood vessel. These patients require prompt reexploration through the same incision, complete evacuation of the blood clots, and identification of the bleeding point.

Hemobilia. Bleeding through the T-tube indicates hemobilia. It may arise from intrahepatic trauma during attempts to extract an intrahepatic calculus. Generally, expectant therapy is sufficient in any vitamin K deficiency has been corrected preoperatively. In case of persistent hemobilia, perform hepatic arteriography, as iatrogenic trauma to a specific branch of the hepatic artery during the hepatic duct exploration may be the source of bleeding. This is a rare complication, with a reported incidence of less than .1 %. Treatment consists of transcatheter embolization in the angiography suite. If open exploration is required, a T-tube cholangiogram plus the hepatic arteriogram may help the surgeon identify the appropriate vessel to ligate.

Residual CBD Stone

Early Postoperative Treatment. Most often a residual CBD stone is detected when postoperative T-tube

cholangiography is performed. When this study is read as positive for calculi by the radiologist, carefully review the films. Request a repeat study to rule out the possibility that the shadow is due to an air bubble. Shadows that are odd in shape may not be calculi but may be due to residual blood clot or debris. There is no need for early operative intervention aimed at removing a residual CBD stone so long as the T-tube is draining well. This is true because the nonoperative methods of extracting calculi are extremely effective and have a low complication rate. Also, some of the radiographic shadows, interpreted as calculi, may indeed be artifacts that disappear without treatment.

If the radiographic evidence is convincing and a stone less than 1 cm in diameter is seen in the lower portion of the CBD, a saline flush with or without heparin solution may be indicated if tolerated by the patient. This should not be performed before the 12th postoperative day. Infuse 1,000 ml of normal saline with 5,000 units of heparin through the T-tube over a 24-h period, provided it does not produce excessive pain. If the calculus completely blocks the distal CBD, this technique is contraindicated. Repeat this therapy every day for 4–5 days if tolerated. Then repeat the cholangiogram. If the radiographic appearance of the stone shows a reduction in size, repeat the series of saline flushes the following week. Otherwise, send the patient home with the T-tube in place. If the stone is not obstructing and the patient tolerates clamping of the T-tube, keep the tube clamped. Prescribe a choleretic such as Decholin to dilute the bile. Otherwise, have the patient inject 30–60 ml of sterile saline into the T-tube daily. Ask the patient to return to the hospital about 6 weeks following operation.

Subsequent Postoperative Treatment. When the patient returns for examination 6 weeks after the operation, repeat the T-tube cholangiography to confirm the persistence of the residual stone because in a number of cases the calculus spontaneously passes into the duodenum. The simplest, safest method for extracting residual calculi is that described by Burhenne. With this method it is necessary that the long arm of the T-tube be at least the size of a 14–16 F catheter. After cholangiography is completed and confirms the presence of stones, remove the T-tube and insert a flexible catheter that can be manipulated, such as the one available from Medi-Tech. With a continuous flow of contrast medium through the catheter, insert the device down the T-tube track until the CBD has been entered. Then, directing the tip of the catheter toward the calculus, insert a Dormia stone basket device through the Medi-Tech catheter. Under fluoroscopic control, trap the stone in the stone basket and withdraw the basket, the stone, and the catheter through the T-tube track. Experienced radiologists such as Burhenne have reported a success rate better than 90 % with this technique. If the stone is quite large, it may not fit into the T-tube track. Large stones are not commonly left behind by competent surgeons, so almost all residual stones can be removed by this technique. It is even possible to cannulate the right and the left hepatic ducts to remove stones. Another method for accomplishing the same end is to pass a flexible fiberoptic choledochoscope into the CBD via the T-tube track.

If these methods have failed, endoscopic papillotomy by ERCP should be tried *if an expert is available*. Experience endoscopists have reported performing ERCP-papillotomy and extraction of retained stones with 1–2 % mortality. If expertise with this technique is not available, a stone blocking the flow of bile to the CBD requires relaparotomy and choledochotomy for removal. A CBD stone that is not symptomatic when the T-tube is clamped presents a more difficult problem. Some surgeons elect to remove the T-tube, continue to observe the patient, and reserve reoperation for patients who later become symptomatic. Alternatively, it may well be argued that it is safer to perform an elective operation to remove the stone than an urgent procedure in the presence of cholangitis. In most cases elective choledocholithotomy is indicated (see Chap. 81).

Further Reading

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