OVERVIEW

The first successful common bile duct (CBD) exploration by Thornton in 1889 and the introduction of catheter-based biliary decompression by Courvoisier and Kehr marked the initial efforts in treating choledocholithiasis. Open cholecystectomy and bile duct exploration were performed commonly as the standard treatment for patients with choledocholithiasis for many years with good success and low rates of morbidity and mortality. During this era of open operative interventions, the percentage of retained stones was only 1% to 3%, and long-term follow-up revealed that revisional surgery was necessary in only about 10% of the patients. (Gonzalez et al, 1997; Hammarström et al, 1995; Neoptolemos et al, 1987; Targarona et al, 1996).

In the last several decades, however, there has been a shift away from routine open cholecystectomy and CBD exploration with improvements in noninvasive imaging and increasing sophistication of percutaneous and endoscopic interventions (see Chapters 19, 29, 30, and 36C). Beyond the widespread availability of endoscopic retrograde cholangiopancreatography (ERCP) the increased use of laparoscopy and minimally invasive techniques has made open CBD exploration an infrequently used tool. Although the majority of cholecystectomy stones are now performed laparoscopically (see Chapter 35), laparoscopic CBD exploration (LCBDE; see Chapter 36B) has not been similarly embraced. This is in part because of the wide availability of ERCP but also in part because the technical demands of LCBDE do not lend itself to routine use by most general surgeons. Surveys of general surgeons practicing in a rural area of the United States demonstrated that the preferred approach to choledocholithiasis was ERCP (75%), followed by laparoscopic (21%) and open (4%) exploration. Time constraints and lack of equipment were the main factors preventing the application of the laparoscopic technique for treating choledocholithiasis (Bingener & Schwesinger, 2006).

Despite these considerations, there remain indications for operative choledochotomy and, more specifically, for open exploration. This chapter presents a review of the clinical features of choledocholithiasis with an emphasis on the technical aspects of open CBD exploration.

ORIGIN OF CHOLEDODCHOLITHIASIS

CBD stones are broadly classified by their location of origin (see Chapter 32). Secondary stones, those that originate in the gallbladder and migrate into the bile duct, are the most common. Chemically, these stones tend to be cholesterol or black-pigment stones. Primary CBD stones, in contrast, originate within the CBD and are predominantly brown-pigment (calcium bilirubin) stones. Primary stones occur in patients with congenital absence of the gallbladder and in those whose CBD had been cleared at the time of prior cholecystectomy. CBD stones that occur in the immediate postcholecystectomy period should be assumed to be secondary stones that are the result of an incompletely cleared CBD. Although secondary stones are the most commonly observed CBD stones, particularly in Europe and North America, primary stones are encountered more commonly in Asia. This is associated with the high incidence of intrahepatic bile duct stones seen primarily in Southeast Asian countries, Taiwan, Hong Kong, and Singapore (Kim et al, 1995) (see Chapter 39). The relative prevalence of intrahepatic bile duct stones in all gallstone cases in Taiwan is extremely high (>50%), and coexisting intrahepatic and extrahepatic bile duct stones are found in approximately 70% of these.

Inflammatory, infective, and congenital typical presentations of choledocholithiasis include biliary colic, jaundice, cholangitis (see Chapter 43), and pancreatitis (see Chapter 55). Of these, pain from biliary colic tends to be the most common symptomatology of CBD stones. In many cases, the intermittent obstruction and passage of CBD stones will result in fluctuating elevation of bilirubin and liver function enzymes. If untreated for a long period of time, these recurrent episodes may lead to secondary biliary cirrhosis. In contrast to the intermittent obstruction that results in biliary colic, persistent CBD obstruction can result in cholangitis, which presents with Charcot’s classic triad (fever/rigors, jaundice, and right upper quadrant pain) or Reynold’s pentad (Charcot’s triad plus hypotension and altered mental status) (see Chapter 43). Pancreatitis is the second most frequent symptomatic presentation of CBD stones (see Chapter 55), and depending on the timing of cholangiography, CBD stones can be identified in up to 50% of these patients. Patients who have symptomatic bile duct stones are at risk of experiencing further symptoms or complications if left untreated. More than one half of patients who had retained bile duct stones experienced recurrent symptoms during a follow-up period of 6 months to 13 years (Johnson & Hosking, 1987), and 25% developed serious complications (Caddy & Tham, 2006). The potential for serious sequelae related to CBD stones makes the identification and ultimate treatment of patients with CBD stones of great importance.

The potential long-term sequelae of untreated clinically significant stones has led some to advocate for routine intraoperative cholangiography at the time of cholecystectomy so that clearance of the duct at the time of surgery can be ensured. The clinical significance and natural history of asymptomatic CBD stones, however, is unpredictable, as many small stones...
will pass spontaneously without incident. During the era of open cholecystectomy, the practice of routine cholangiography was common, and studies from this period demonstrated an incidence of choledocholithiasis approaching 10% to 15% in patients without any clinically evident common duct involvement (Coelho et al, 1984; DenBesten & Berci, 1986; Doyle et al, 1982; Ganey et al, 1986; Girard, 2000; Hampson et al, 1981; Lygidakis, 1983; McSherry & Glenn, 1980). This has caused some to advocate for the utility of routine intraoperative cholangiography, even in patients without clinical signs of choledocholithiasis. Proponents of a more selective approach to cholangiography, however, note that the percentage of clinically significant stones is lower than the 10% to 15% of patients who will have cholangiographic findings of CBD stones when routine cholangiography is used.

The use of selective intraoperative cholangiography in laparoscopic cholecystectomy series demonstrates similar findings (Fogli et al, 2009). Collins and colleagues (2004) identified filling defects consistent with stones in 4.6% of patients on intraoperative cholangiogram. In these patients, access was maintained for the performance of postoperative cholangiograms. At 48 hours, 26% of patients had a normal cholangiogram, and an additional 26% had evidence for passage of the stones by 6 weeks. Twenty-two patients (2.2%) had persistent CBD stones at 6 weeks after laparoscopic cholecystectomy and underwent ERCP for retrieval (Collins et al, 2004).

PREOPERATIVE DIAGNOSIS

In the absence of clinical signs such as cholangitis or pancreatitis, preoperative identification of choledocholithiasis typically relies on serum liver function tests (LFTs) and imaging studies. The utility of LFTs in predicting the presence of CBD stones has been demonstrated by a number of groups (Peng et al, 2005; Sgourakis et al, 2005). Serum bilirubin and alkaline phosphatase are typically the most commonly used laboratory values; however, a raised y-glutamyltransferase level has been suggested to be the most sensitive and specific laboratory indicator of CBD stones. A value greater than 90 U/L has been proposed to indicate a high risk of choledocholithiasis, with sensitivity and specificity of 86% and 74.5%, respectively (Peng et al, 2005).

When used in conjunction, clinical examination, laboratory studies, and ultrasonography (typically the first-line imaging modality) (see Chapter 15) are sensitive in 96% to 98% and specific in 40% to 75% for identification of patients with choledocholithiasis (Alponat et al, 1997; Koo & Traverso, 1996; Trondsen et al, 1998). Liu and colleagues (2001) stratified precholecystectomy patients into four groups of descending risk of choledocholithiasis based on guidelines incorporating clinical evaluation, serum chemistry analysis, and transabdominal ultrasound (TUS). The occurrence of choledocholithiasis in these groups (group 1, extremely high risk; group 2, high risk; group 3, moderate risk; group 4, low risk) was 92.6%, 32.4%, 3.8%, and 0.9%, respectively. Triaging patients in this manner resulted in preoperative identification of choledocholithiasis by ERCP in 92.3% of the patients who were subsequently referred for endoscopic clearance. Similarly, the American Society of Gastrointestinal Endoscopy (ASGE) identified several predictors of choledocholithiasis (ASGE Standards of Practice Committee, et al, 2010) in their guidelines for the use of endoscopy in the evaluation of CBD stones. CBD stones seen on TUS, clinical evidence of ascending cholangitis, and bilirubin greater than 4 mg/dL were identified as “very strong” predictors; dilated CBD on TUS (>6 mm) and bilirubin between 1.8 and 4 mg/dL were “strong” predictors; abnormal LFTs other than bilirubin, age older than 55 years, and clinical gallstone pancreatitis were “moderate” factors. Using these factors, patients are stratified into high, intermediate, and low likelihood for choledocholithiasis groups. Presence of any “very strong” or both “strong” predictors leads to classification as high likelihood for choledocholithiasis. Patients with no predictors are low likelihood, and all others are intermediate.

In patients identified to be at elevated risk for having CBD stones, a thoughtful and efficient approach to subsequent imaging and intervention is required. TUS is the most commonly used initial diagnostic tool for suspected biliary stones because it is noninvasive, widely available, and inexpensive (see Chapter 15). If CBD stones are detected, specificity is high (95% to 100%); however, TUS has low sensitivity (25% to 60%) for detection of CBD stones and is highly operator dependent (Amouyal et al, 1994; Sugiyama & Atomi, 1997). As mentioned previously, indirect evidence such as the presence of gallstones or biliary ductal dilation with a CBD diameter greater than 6 mm in the appropriate clinical setting can be predictive of bile duct stones.

Like TUS, standard computed tomography (CT) scanning has a low sensitivity for the detection of bile duct stones and is most useful in documenting biliary dilation or excluding mass lesions as a cause of biliary obstruction (see Chapter 18). Newer techniques of CT cholangiography use contrast agents excreted in the biliary tree, which combined with high-resolution helical scans and three-dimensional reconstructions can give accurate and detailed information about the biliary tree (Cabada Giadás et al, 2002; Maniatis et al, 2003). The sensitivity of this technique can be as high as 97%, and the specificity is 75% to 96% (Anderson et al, 2008; Cabada Giadás et al, 2002; Gibson et al, 2005; Kim et al, 2007; Kondo et al, 2005; Maniatis et al, 2003; Polkowski et al, 1999; Soto et al, 2000; Zandrino et al, 2005). Although these data suggest accuracy comparable to magnetic resonance cholangiopancreatography (MRCP) (see Chapter 19), helical CT cholangiography is limited by several issues: (1) possible allergic reactions to the contrast agents (as high as 15% in one series using intravenous ioxotrate) (Gibson et al, 2005); (2) suboptimal ductal contrast opacification in the presence of significant jaundice (Poltkowski et al, 1999; Soto et al, 1999); and (3) limited visualization of intrahepatic duct branches (Chopra et al, 2000; Gibson et al, 2005).

MRCP has been the gold standard for noninvasive biliary imaging since its introduction in 1991 (Wallner et al, 1991) and has been recommended by some as the preoperative modality of choice for the detection of CBD stones (Hallal et al, 2005; Shammugam et al, 2005; Taylor et al, 2002; Topal et al, 2003) (see Chapter 17). MRCP provides precise anatomic detail of the biliary tract and has a sensitivity of 81% to 100% and a specificity of 92% to 100% in detecting choledocholithiasis (Hallal et al, 2005; Verma et al, 2006). The accuracy of MRCP in diagnosing CBD stones is comparable with that of ERCP (see Chapters 19 and 20) and intraoperative cholangiogram (IOC) (see Chapter 23) (Hallal et al, 2005; Varghese et al, 2000) but may be somewhat less sensitive than endoscopic ultrasound (EUS) for small stones (Verma et al, 2006). As a diagnostic test, MRCP has largely replaced ERCP, once considered the gold standard of preoperative bile duct imaging,
because the nonselective use of ERCP in all patients with suspected choledocholithiasis detects CBD stones in less than 50% (Behrns et al, 2008; Petrov et al, 2008). Additionally, indiscriminate use of ERCP exposes over half of patients to unnecessary procedure-related morbidity and mortality (Demartines et al, 2000); thus ERCP is better used as a therapeutic intervention rather than a diagnostic one. Although MRCP is currently the most accurate noninvasive imaging modality for choledocholithiasis, it may miss stones smaller than 5 mm in diameter and can underestimate the number of stones detected (Varghese et al, 2000). Furthermore, it is expensive when compared with TUS or CT, not readily available at smaller facilities, and may not be technically feasible in obese patients or those with significant claustrophobia.

EUS has also emerged as an alternative to ERCP and MRCP for preoperative assessment of bile duct stones and was initially described around 1990 (Amouyal et al, 1989; Edmundowicz et al, 1992) (see Chapter 16). The overall diagnostic performance of EUS has been evaluated in numerous prospective studies since then, and in two meta-analyses (Garrow et al, 2007; Tse et al, 2008) the pooled sensitivity and specificity of EUS were 89% to 94% and 94% to 95%, respectively. Randomized controlled trials have also demonstrated that EUS-guided ERCP can avoid unnecessary ERCP in up to two thirds of patients when compared with using ERCP alone for diagnosis of choledocholithiasis (Petrov & Savides, 2009). Furthermore, selective use of ERCP based on EUS findings resulted in reduced risk of overall complications and post-ERCP pancreatitis. When taken in sum, these data suggest that the ERCP is best reserved as a therapeutic measure for patients with a high probability of CBD stones, rather than as an initial diagnostic test.

**TIMING AND SEQUENCE OF INTERVENTIONS**

**Suspected Choledocholithiasis Prior to Cholecystectomy**

In patients with suspected choledocholithiasis, selecting and sequencing the most appropriate of laparoscopic, open, and endoscopic therapeutic modalities can be challenging. Prior to the popularization of laparoscopy, precholecystectomy endoscopic clearance of the CBD was uncommon. Several studies did not reveal any morbidity or mortality advantage with preoperative endoscopic sphincterotomy (Heinerman et al, 1989; Neoptolemos et al, 1988; Stain et al, 1991), and one actually showed an increased rate of morbidity in patients who underwent preoperative ERCP, followed by open cholecystectomy, compared with the group that was treated with single-stage open cholecystectomy and CBD exploration (Stain et al, 1991). A systematic review (Martin et al, 2006) demonstrated that open surgery resulted in less mortality, lower incidence of primary treatment failure, and fewer procedures required per patient. Given these data, single-stage cholecystectomy and bile duct exploration (as indicated) was the preferred approach in the era of open cholecystectomy.

The advent of laparoscopy saw a rise in the popularity of preoperative ERCP CBD clearance for patients with suspected choledocholithiasis, in part because laparoscopic CBD is more technically challenging (see Chapters 36B and 36C). For surgeons who are comfortable with laparoscopic CBD exploration, there are some data that support a single-stage laparoscopic management (laparoscopic cholecystectomy and intraoperative cholangiogram; CBD exploration in those with CBD stones) over preoperative ERCP, followed by laparoscopic cholecystectomy. Several prospective randomized controlled trials compared these two treatment strategies (Cuschieri et al, 1999; Rogers et al, 2010; Sgourakis et al, 2005) and found the two groups had equivalent success rates of duct clearance and patient morbidity, but a significantly shorter hospital stay was reported with the single-stage laparoscopic treatment. Cuschieri and colleagues (1999) concluded that precholecystectomy endoscopic clearance should be reserved for higher-risk patients (those with multiple comorbidities, cholangitis, severe pancreatitis), whereas fit patients (American Society of Anesthesiologists categories I and II) should be treated with a single-stage laparoscopic approach.

When laparoscopic CBD exploration is not part of the surgeon's armamentarium, the decision to perform a precholecystectomy ERCP should be weighed carefully because it is not without complications. Although most post-ERCP complications are mild to moderate in severity (Andriulli et al, 2007), the risk of severe complications, such as pancreatitis, bleeding, infection, and perforation, need to be weighed against the likelihood that ERCP will find clinically relevant CBD stones. ERCP has an overall complication rate of 10% and a mortality rate less than 0.5% (Cotton, 1993; Davis et al, 1997; Delorio et al, 1995; Ponsky, 1992). Additionally, the increased financial cost of preoperative ERCP should be considered when evaluating its role in treatment of suspected stones.

Even using criteria such as elevated LFTs and imaging findings, accurately predicting which patients will have clinically relevant choledocholithiasis is difficult. Several studies have shown that negative ERCP was performed in 40% to 70% of patients because most of these biochemical and radiographic abnormalities were the result of transient biliary obstruction secondary to stones that ultimately passed into the duodenum (Cotton, 1993; Cuschieri et al, 1996; Delorio et al, 1995; Stain et al, 1991; Ponsky, 1992). As mentioned earlier in this chapter, the ASGE published a system to grade likelihood of choledocholithiasis into high, intermediate, and low likelihood groups based on risk factors, including LFTs, bile duct size on imaging, and presence of gallstone pancreatitis or cholangitis (ASGE Standards of Practice Committee, et al, 2010). Treatment strategies for patients stratified to the low and high likelihood groups are generally agreed upon. Patients who are in the low risk for choledocholithiasis group should go directly to laparoscopic cholecystectomy (with or without IOC) because CBD clearance is unlikely to be necessary.

For patients in the high-risk group, particularly those needing biliary decompression for treatment of acute cholangitis (Cuschieri et al, 1999; Leung, 2003) and in patients with severe gallstone pancreatitis and evidence of persistent choledocholithiasis, precholecystectomy ERCP is warranted. Patients with multiple medical comorbidities, limited life expectancy, or other issues that would make them poor surgical candidates, ERCP with endoscopic sphincterotomy (ES) and biliary decompression can sometimes be used as the definitive management without cholecystectomy (see Chapter 29). This strategy is not ideal for patients who are acceptable surgical candidates, however, because there is a risk of recurrent biliary symptoms if cholecystectomy is not performed. In a prospective randomized trial published in 1995 by Hammarström and colleagues, an expectant policy after ES was compared with open
cholecystectomy combined with CBD exploration. It was reported that 20% of the patients after ES alone needed cholecystectomy during follow-up (Hammarström et al., 1995). A prospective randomized trial of high-risk patients performed by Targarona and colleagues (1996) comparing ES and subsequent open cholecystectomy to ES alone resulted in similar findings. They noted patients who underwent elective open cholecystectomy had significantly fewer recurrent biliary symptoms (6% vs. 21%) and needed fewer readmissions (4% vs. 23%) than patients who did not undergo surgery after ES.

In contrast to the general consensus of how to treat high- and low-likelihood patients, the question of how to treat intermediate-risk patients has been the subject of some debate. A recent randomized clinical trial (Iranmanesh et al., 2014) examined an upfront cholecystectomy and IOC strategy against preoperative ERCP and subsequent cholecystectomy for intermediate-risk patients. Fifty patients were randomized to each group, and differences in length of stay, number of subsequent CBD interventions, morbidity, mortality, and quality of life were analyzed. No significant difference was found in morbidity or quality of life; however, patients who underwent cholecystectomy as the initial procedure had a significantly shorter length of stay (median, 5 days vs. 8 days; \( P < .001 \)) and fewer common duct investigations. Based on these findings, the authors suggested that initial cholecystectomy with intraoperative cholangiogram may be the preferred approach. In any patient being considered for precholecystectomy ERCP, strong consideration should be given to the use of EUS (with selective ERCP) or MRCP because these studies are less invasive and have minimal risk compared with that of an ERCP.

**Common Bile Duct Exploration at Time of Open Cholecystectomy**

Laparoscopy has become routine in much of the world, and as laparoscopic experience has grown, surgeons have become increasingly more comfortable using laparoscopic CBD exploration when choledocholithiasis is noted intraoperatively. In areas of the developing world, however, where access to endoscopic, radiologic, and laparoscopic expertise is limited, open cholecystectomy and bile duct exploration remains a mainstay of treatment. Even in settings where laparoscopy and endoscopy are readily available, however, there will still be some patients in whom an open approach to CBD exploration may be required (see Chapters 36B and 36C). Principal among these include (1) patients with large or impacted CBD stones and those who have failed previous endoscopic interventions, in whom biliary enteric drainage is indicated; (2) those with anatomic considerations that preclude endoscopic treatment, such as prior gastric resection or duodenal diverticulae; and (3) patients who require an open approach for cholecystectomy, including those with Mirizzi syndrome, biliary-enteric fistula, severe cholecystitis, or a high index of suspicion for cancer.

**Postcholecystectomy Choledocholithiasis**

*(See Chapter 38)*

**Incidence**

The majority of initial operations for gallstone disease, with or without demonstrated choledocholithiasis, are curative, but some patients will develop sequelae of choledocholithiasis post-cholecystectomy. Approximately 1% to 2% of all patients who undergo cholecystectomy have stones left in the CBD that require further intervention (Roslyn, 1993). Retained calculi occur rarely after open cholecystectomy without CBD exploration (Bergdahl & Holmlund, 1976), whereas incidence in those who undergo open cholecystectomy with concomitant CBD exploration is slightly higher but still reported to be less than 5% (Dayton et al., 1984; Kappes et al., 1982; Roslyn, 1993). Retained CBD stones occur with higher frequency after positive CBD exploration than after a negative one. The rate of recurrence increases to approximately 20% after a second operation on the biliary tract for choledocholithiasis (Saharia et al., 1977; Way, 1973), and this rate increases after subsequent reoperation (Allen et al., 1981).

**Treatment**

Endoscopic and percutaneous methods remain the preferred modalities when managing recurrent or retained CBD stones (see Chapters 30 and 36C). The open surgical approach is reserved for patients who have failed nonoperative treatments. Decision making is further influenced by clinical presentation, condition of the patient, institutional expertise, and presence or absence of a T-tube.

**Retained Stones in the Presence of a T-tube.** The rise in popularity of laparoscopic biliary surgery has also meant decreasing use of the T-tube. Even when laparoscopic CBD exploration is performed, primary closure has been shown to be safe (Dong et al., 2014; El-Geidie, 2010; Gurusamy et al., 2013), and routine use of postexploration T-tubes is not common (see Chapters 31 and 42). If a T-tube is present, it provides noninvasive options for accessing the biliary tree postoperatively. In the presence of a T-tube, retained CBD stones in the immediate postoperative period can be managed with observation, mechanical extraction, or ES.

If choledocholithiasis is noted within the first 4 to 6 weeks postoperatively, no treatment is typically necessary, assuming there is no evidence of obstruction or cholangitis. In the initial weeks after CBD exploration, 10% to 25% of retained stones found on postoperative cholangiography will pass spontaneously into the duodenum, and no further treatment is required. If calculi persist after 4 to 6 weeks, treatment options include radiologic approach through the T-tube tract (see Chapter 30) or ERCP (see Chapter 29). Because of its high success rate and low morbidity and mortality, nonoperative mechanical extraction through the T-tube tract is an attractive treatment choice. A success rate of 95% has been reported with a morbidity rate of only 4% (Mazzariello, 1978). Burhenne (1980) reported no deaths in 661 patients. When complications do occur, they can be treated medically in most instances, and only 0.2% of cases have required surgery (Mazzariello, 1978).

ES also has been shown to be effective in the management of retained stones in the early postoperative period after exploration of the CBD with a T-tube still in place (Hammarström et al., 1996; O’Doherty et al., 1986). Although ES has the considerable advantage that it can be carried out as soon as retained stones are discovered, treatment may be unnecessary in some patients because stones may pass spontaneously. Some authors (Lambert et al., 1988) have suggested that mechanical stone extraction through the T-tube tract is superior to ES because of its high success rate and lower morbidity profile, although modern endoscopic equipment may mitigate some of the post-ERCP hemorrhagic complications seen in earlier series (Christoforidis et al., 2004). Regardless, the safety and efficacy
of percutaneous intervention through the T-tube makes it an ideal choice for initial postoperative interventions, and ES is best used in the early postoperative period before a T-tube tract is well formed, when the patient is clinically unstable, the T-tube is inappropriate in size and position, or mechanical extraction through the T-tube has failed. If these techniques fail, operative management can be undertaken with the expectation of a high success rate and acceptable morbidity and mortality (Cameron, 1989; Girard & Legros, 1981).

**RETAIRED OR RECURRENT STONES IN THE ABSENCE OF A T-TUBE.** ES is the procedure of choice and should be attempted first in patients without a T-tube in place (Cameron, 1989; Sivak, 1989) (see Chapters 29 and 36C). Most reports of ES indicate a success rate in achieving overall clearance of stones from the CBD of more than 85% (Cotton, 1984; Dasari et al, 2013; Lambert et al, 1991). Although early complication rates for ES range from 5% to 15%, emergency surgery is uncommonly required and most complications can be managed conservatively (Cotton, 1984; Dasari et al, 2013; Escourrou et al, 1984). Hemorrhage, pancreatitis, cholangitis, and perforation are the most frequent complications, and mortality usually is reported at 0.5% to 2% (Lambert et al, 1991; Sivak, 1989). Long-term complication rates, mainly from stenosis or new stones or both, are low (<10%), and most complications can be managed endoscopically (Cotton, 1984; Escourrou et al, 1984; Hammarström et al, 1996; Sivak, 1989).

If ES is unsuccessful, percutaneous transhepatic rendezvous techniques can sometimes aid in duct clearance, particularly if there is difficulty cannulating the ampulla. Often, however, failures of endoscopic management will be the result of large impacted stones or anatomic issues that are not ameliorated by a percutaneous approach. In such settings, operative management is the most reasonable alternative (Cameron, 1989). Reoperation for retained stones can be performed safely, with operative mortality less than 2% (Girard & Legros, 1981). Miller and colleagues (1988) reported 237 patients with CBD stones treated by CBD exploration or ES. Success was higher and mortality was lower for the operatively managed group. The complication rate was similar, but the complications tended to be more serious and more apt to require surgery in the ES group. A systematic review performed by Dasari and colleagues (2013) found that duct clearance in patients undergoing open bile duct exploration was superior to ES, but it should be noted that most series that compare open cholecystectomy/CBD exploration to ES are from the era of open surgery, which also corresponds to the early days of ERCP and ES. Therefore caution should be used in extrapolating these data to the modern endoscopic experience. Nevertheless, these findings reinforce that surgery can be a valuable, effective, and safe tool in the treatment of recurrent/retained CBD stones, even if confined to the subset of patients who fail ES.

When reoperation is required for retained CBD stones, the optimal procedure is complete removal of all stones via choledocholithotomy, choledochoscopy, placement of a T-tube (in many cases), and completion cholangiography. This procedure is adequate for most patients, and the overall failure rate is has been reported as low as 3% (Girard & Legros, 1981). Others, however, have reported significantly higher failure rates (Allen et al, 1981; Saharia et al, 1977), which has prompted some authors (Allen et al, 1981; Lygidakis, 1982) to recommend biliary-enteric drainage in all patients with previous choledocholithotomy. Tompkins and Pitt (1982) and Cameron (1989) emphasized, however, that concomitant biliary drainage should not be regarded as mandatory procedure in all patients with retained or recurrent stones. In general, biliary-enteric drainage at reoperation is appropriate in the following scenarios: (1) stricture or stenosis of the distal bile duct or sphincter of Oddi, (2) marked dilation of the duct of 2 cm or more, (3) multiple or primary bile duct stones, (4) inability to remove all stones from the duct, and (5) a third operation.

Transduodenal sphincteroplasty, choledochoduodenostomy, and choledochojjunostomy are effective methods of biliary enteric drainage (Braasch et al, 1980; Johnson & Harding Rains, 1978; Jones, 1978) (see Chapter 31). With the wide availability of ERCP, operative sphincteroplasty is rarely required because ES is sufficient in most cases. In the presence of a long distal CBD stricture, ES is not an appropriate choice because it does not address the primary obstructive issue. For ducts smaller than 1 to 1.5 cm in diameter, sphincteroplasty is the preferred operative approach as this avoids possible anastomotic stricture formation, but it does carry a greater risk of postoperative pancreatitis. Occasionally, recurrent or primary stones will be seen in patients with dilated ducts and a widely patent sphincter after sphincteroplasty or sphincterotomy. In such cases, choledochoduodenostomy or Roux-en-Y choledochojjunostomy is necessary. Side-to-side or end-to-side choledochoduodenostomy and end-to-end Roux-en-Y choledochojjunostomy are excellent drainage options for CBDs larger than 1.5 cm and offer better decompression of an extremely large duct. In the context of previous biliary pancreatitis, patients who present for reoperation with multiple stones and an incompletely cleared proximal biliary system may be better served with an end-to-side choledochojjunostomy as opposed to a side-to-side technique because it minimizes the chance of stones dropping distally and causing recurrent pancreatitis. Sump syndrome is an uncommonly observed complication of choledochoduodenostomy and should be managed initially by endoscopic modalities. If ERCP fails to improve symptoms, the choledochoduodenostomy can be converted to a Roux-en-Y choledochojjunostomy.

**Clinical Experience With Reoperation**

Girard (2000) reviewed all patients who underwent reoperation for retained or recurrent choledocholithiasis at the Maisonneuve-Rosemont Hospital between 1969 and 1990. Eighty-five patients with preoperatively confirmed choledocholithiasis underwent a total of 88 operations. Eighty-five of these operations were second procedures, and three patients required a third operation. Three types of bile duct reoperation were performed: choledocholithotomy with T-tube drainage (64 patients), choledocholithotomy with side-to-side choledochojjunostomy (15 patients), and choledocholithotomy with transduodenal sphincteroplasty (6 patients). Choledocholithotomy with T-tube drainage in 1 patient and choledocholithotomy with side-to-side choledochojjunostomy in 2 patients were performed at a third operation.

The average hospital stay was 9.3 days. There were no deaths in the series despite the fact that 43 of 85 patients were older than age 60 years and 44 patients had associated risk factors. Six minor complications were observed, none of which necessitated urgent surgery. Two patients (3%) of the 64 who had choledocholithotomy with T-tube drainage developed recurrent bile duct stones 4 and 5 years after a second
operation, and side-to-side choledochoduodenostomy was performed.

Taking Girard’s (2000) experience with that of other reported series, there have been 15 deaths among 920 patients submitted for reoperation for recurrent bile duct stones (Table 36A.1). In one of these series (McSherry & Glenn, 1980), choledocholithotomy was done for retained or recurrent stones in 341 patients; 7 patients died after the procedure, resulting in a mortality of 2%. If three of these deaths that occurred after urgent operations for cholangitis or pancreatitis are excluded, however, and only the elective procedures are considered, only 4 patients died (1%) after repeat choledocholithotomy. These results show that the overall mortality rate for retained or recurrent stones is less than 2%, with most deaths occurring in elderly patients. This mortality rate is comparable to that of ES.

To summarize, ES has become the first-line therapy for retained or recurrent bile duct stones, but surgery can be performed safely with low mortality and morbidity when required. Surgery remains a critical component of the armamentarium that can be used to treat recurrent bile duct stones. As with most things in modern medicine, a multidisciplinary approach to recurrent CBD stones is important to properly select and sequence the numerous options now available. Gastroenterologists, radiologists, and surgeons should work together closely to assess the most appropriate intervention for an individual patient. In making the choice between open surgery, laparoscopic surgery, percutaneous therapies, and ES, the surgeon must consider not only the published data but institutional expertise and experience. In a patient with a retained stone and a T-tube in place, percutaneous extraction through the T-tube tract or ES should be attempted first. In the absence of a T-tube, ES should be attempted first. If unsuccessful or contraindicated, operative management is a reasonable alternative. Surgical intervention has a high success rate and acceptable rates of mortality and morbidity. Before operation, the surgeon must make an accurate diagnosis of retained stones by using a combination of MRCP, ERCP, and US. These findings should be confirmed via intraoperative cholangiography and complete clearance of the biliary tree documented with completion cholangiography and choledochoscopy. Most patients do not require biliary-enteric drainage, but certain patients, particularly those with multiple or incompletely cleared calculi, large ducts (>2 cm), and distal CBD strictures, will benefit from drainage procedure.

### SURGICAL TECHNIQUES FOR EXPLORATION OF THE COMMON BILE DUCT

The principal techniques for open exploration of the CBD will be detailed in this section. Broadly, the goals of CBD exploration include complete clearance of calculi from the biliary system and establishment of free flow of bile into the gut. The preferred approach to CBD exploration is typically through a supraduodenal choledochotomy, with the transduodenal/transampullary route reserved for patients with impacted stones that cannot be removed readily from above. Stones impacted at the ampulla can be broken down and removed through a supraduodenal approach; however, a transduodenal sphincteroplasty is generally less traumatic.

Clearance of the biliary tree should be confirmed by performing postexploratory choledochoscopy and cholangiography. The value of choledochoscopy has been confirmed by many authors (Dayton et al, 1984; Kappes et al, 1982; Nora et al, 1977). Postexploratory cholangiography should also be performed prior to closure of the abdomen, not only because it can locate missed stones, but also because it may reveal unsuspected disruption of the biliary ductal system. If cholangiography technique is meticulous, issues with false positives from air bubbles and poor opacification of the entire system can be largely eliminated to provide consistent and reliable cholangiograms.

The selective use of biliary-enteric drainage procedures is another method to decrease the incidence of subsequently symptomatic retained stones. Although we do not recommend routine biliary-enteric decompression at initial operation, it should be considered carefully in patients with multiple duct stones, particularly in those with large stones; dilated ducts; and in elderly patients. If these conditions pertain in an elderly or poor-risk patient, choledochoduodenostomy may obviate reexploration. Other indications include (1) the presence of irretrievable intrahepatic stones, (2) proven ampullary stenosis, or (3) an impacted ampullary stone.

### Supraduodenal Choledochotomy and Exploration of the Common Bile Duct

#### Exposure

The liver is retracted superiorly with a broad-bladed, slightly curved retractor, such as a Hartmann (“sweetheart”) retractor. This retractor should be deep enough to displace the liver but not so curved as to traumatize it. A pack should be put over the hepatic flexure of the colon down to the hepatorenal pouch and the medial part of the duodenum. This pack is retracted by a similar, broad-bladed retractor to prevent the colon or duodenum from obscuring vision (Fig. 36A.1). The lesser omentum and stomach are retracted to the left after placement of another pack. The gallbladder is usually removed before exploration of the CBD because it may obstruct vision, although in some cases it can be a useful aid to retraction. Palpation of the CBD and handling of its lower part during exploration and subsequent choledochoscopy cannot be done properly without having performed a classic Kocher maneuver (Fig. 36A.2).

#### Choledochotomy

A distal vertical supraduodenal choledochotomy is generally preferred for several reasons. First, because a choledochoduodenostomy may be required (see Chapter 31), the opening
should be positioned in the lowest part of the supraduodenal CBD such that an anastomosis can be created easily and without tension (Figs. 36A.3 and 36A.4). Second, a distal choledochotomy leaves the maximal amount of bile duct proximally so that it may be used in the future for an additional procedure (e.g., repair of a stricture). Third, the usual distance from this point to the papilla measures 7 cm or more, which is the exact length of the rigid choledochoscope sometimes used for CBD exploration; this is less of an issue when using a flexible scope, which is typically much longer.

The anatomy of the cystic duct is highly variable, and care must be exercised to open the correct duct (see Chapter 2). A cystic duct lying anterior or closely applied to the CBD can be easily opened in error, particularly if dilated. Bile is aspirated by gentle suction, and a specimen should be sent for culture (Fig. 36A-5).

**Exploration of the Duct**

All efforts must be made to minimize trauma related to the exploration, and rigid instruments should be avoided if possible, as false passages into the duodenum and pancreas can be easily created (Gunn, 1983; Orloff, 1978). Grasping forceps of any type can catch the duct wall and result in delayed stricture formation. Use of the Fogarty balloon catheter can avoid these issues and has been found to be suitable for CBD exploration (Fogarty et al, 1968; Fox & Gunn, 1984).

The Fogarty probe is held in long forceps with the surgeon’s dominant hand and introduced into the CBD (Fig. 36A.6). The catheter is then passed into the duodenum. The balloon is inflated, and the catheter is withdrawn until it impinges against the papilla (Fig. 36A.7). The balloon is identified in the second part of the duodenum by palpation, and the location is noted as the site of duodenotomy should a sphincteroplasty become necessary. Stones can usually be felt against the shaft of the catheter within the duct. The balloon is deflated and gently withdrawn through the papilla, and then the balloon is reinflated immediately. Passage back through the ampulla can be detected by a sudden easing of the pull on the catheter. At this point, the syringe is held in the surgeon’s nondominant hand, and the degree of balloon inflation is controlled by the thumb and the plunger. With gentle traction superiorly from long forceps held in the surgeon’s dominant hand, the catheter is gradually pulled up to the choledochotomy site (Fig. 36A.8), with care being taken to prevent any stone slipping into the proximal biliary tree. If the traction is anterior rather than superior, there is the risk of lacerating the opening into the duct (Fig. 36A.9), and the risk is increased when the opening in the duct is longitudinal. The procedure is repeated until the distal duct is considered to be clear.

Next, this procedure is repeated for the proximal ducts by reinserting the catheter upward into each of the main hepatic ducts. The degree of balloon inflation is of great importance here, as overinflation will result in damage to the ducts and...
FIGURE 36A.3. The common bile duct is opened just above the duodenum to leave room for a choledochoduodenostomy if necessary.

FIGURE 36A.4. Two fine absorbable stay sutures are used to lift and render the common bile duct (CBD) tense for an incision about 1 to 2 cm long, depending on the size of the duct and the size of the stones. If the CBD is not made tense, damage can be done to the posterior wall, or an irregular incision can be made.

FIGURE 36A.5. A, The cystic duct may lie anterior to the common bile duct (CBD) and may be opened in error. B, The cystic duct may run parallel to the CBD with a low entrance, mimicking a dilated duct.
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FIGURE 36A.6. A Fogarty catheter is fed into the duct with forceps by using the dominant hand. The operator’s nondominant hand is used to grasp the mobilized duodenum, which allows palpation of the passage of the catheter and of any stones within the intrapancreatic portion of the common bile duct.

underinflation risks missing stones. Correct inflation can be achieved by inflating the balloon until the tension of the syringe plunger can be felt in the fingers. This tension is maintained as the catheter is withdrawn into the gradually widening duct. It is important to remove the stone when it appears at the choledochotomy opening and to avoid letting it fall into another part of the duct.

The next step in CBD exploration is to irrigate the duct generously with saline. Small stones, sludge, and debris can be flushed into the duodenum or back into the choledochotomy opening by irrigating the ductal system. Finally, the Fogarty catheter is passed again into the duodenum, and the balloon is inflated and retracted against the papilla. While the catheter is held in the surgeon’s dominant hand, the index and middle fingers of the other hand are placed posterior to the duodenum with the thumb anterior; this allows palpation of the duct against the wall of the catheter for any residual stones.

Postexploratory Investigations

Following exploration, the surgeon must make every effort to ensure that the duct system is normal using choledochoscopy and cholangiography (see Chapter 23).

Choledochoscopy

Choledochoscopy is the established method to ensure that the duct system is normal. Modern instruments are small enough to allow visualization of the major right and left hepatic ducts and intermediate hepatic ducts and to allow visualization of the orifices of the smaller biliary radicles. Although flexible scopes carry a higher cost and are more difficult to maintain compared with rigid scopes, they allow for less traumatic choledochoscopy, are more versatile because of their increased length, and allow introduction of therapeutic instruments through the working channel. Some surgeons experienced in choledochoscopy recommend exploration of the CBD and removal of stones under direct vision by using the choledochoscope (Berci, 2000). This can be facilitated by use of a stone basket through the working port of a flexible choledochoscope. The use of
Inflammator y, Infective, and Congenital

**FIGURE 36A.8.** A, The balloon is withdrawn gently, revealing the stone. B, Long forceps can be used to obstruct the common hepatic duct to prevent the stone from slipping upward.

**FIGURE 36A.9.** Angled traction on the Fogarty catheter can result in tearing of the lower end of the choledochotomy.

Grasping or biopsy forceps should be avoided if possible because these instruments can damage the bile duct.

**T-Tube Cholangiography**

After insertion of a T-tube and closure of the choledochotomy, T-tube cholangiography should be performed to ensure adequate clearance of the biliary system. With proper technique and use of fluoroscopy, T-tube cholangiography is an excellent tool for detecting residual stones after CBD exploration (Fig. 36A.10). The cystic duct stump, a possible location of residual stones, can be delineated, and incorrect placement of the T-tube can be detected to prevent complications after the operation. In case of residual stones, the T-tube has to be removed, and the duct needs to be explored again; this necessitates a second suture of the CBD, which is a disadvantage of T-tube cholangiography.

**T-Tube Drainage.** The standard practice is to use a T-tube to allow spasm or edema of the sphincter to settle after the trauma of the exploration. Failure to drain the duct might theoretically result in a buildup of pressure in the extrahepatic ductal system and cause leakage at the disruption of the closure of the duct, along with biliary peritonitis. As noted earlier in this chapter, several series have not found any decreased risk for bile leak with placement of a T-tube and have in fact noted increased operative times and length of stay (Gurusamy et al, 2013). Routine use of a T-tube has, therefore, been questioned. The main role of T-tube placement, therefore, is not to prevent a bile leak but rather to allow an avenue for subsequent treatment of retained stones in high-risk patients. In the event of a retained stone, the T-tube can be useful later for interventional radiologic techniques through the tract created by the tube (Fig. 36A.11) or even direct choledochoscopy. The size of the T-tube should be adapted to the diameter of the CBD, and 14 Fr is the smallest size that should be used. Use of a smaller tube will not result in a satisfactory tract for subsequent interventional radiology procedures.

**T-Tube Placement.** First, the limbs of the T-tube must be shortened (Fig. 36A.12A). T-tubes can become obstructed, particularly if they are tight fitting, and they can be difficult to extract.
This situation can be avoided by cutting off a strip of the wall (Fig. 36A.12B). The practice of dividing the back wall of the T-tube makes subsequent interventional radiology more difficult because the guidewire lodges in the posterior defect. This problem can be avoided by making the length of the T-tube appropriate or by limiting the division of the T-tube. The modified T-tube is held in Desjardin forceps, which conveniently grasps the T-junction of the tube, allowing it to be slipped into the choledochotomy (Fig. 36A.13). The long limb of the tube is placed at the lower end of the opening, and repair is begun just above the upper apex of the incision by using continuous or interrupted absorbable fine sutures. The final stitch should close the opening against the T-tube (Fig. 36A.14).

**AVOIDING PROBLEMS IN THE CLOSURE OF THE CHOLEDOCHOTOMY.**

When closing the choledochotomy over a T-tube, care must be taken to ensure that the wall of the T-tube is not caught in one of the sutures or accidentally affixed to the CBD wall. If this occurs, there is a risk of laceration of the CBD when the T-tube is eventually removed. The proximal limb of the T-tube should be shortened so that it does not enter and obstruct one of the hepatic ducts (Fig. 36A.15). The distal limb should be similarly shortened so that it does not enter the duodenum because, if the tube does, it can act as a siphon. Furthermore, a tube extending through the papillary orifice may incite pancreatitis. The correct position of the T-tube is with the long limb emerging under the costal margin laterally (Fig. 36A.16). This position facilitates radiologic techniques for later postoperative removal of stones should this be necessary. A suction drain is
FIGURE 36A.12.  A, The T-tube is modified by shortening the limbs to prevent proximal obstruction and distal entry into the duodenum. B, A T-tube is modified by removing half the diameter to prevent obstruction and enable easy removal.

FIGURE 36A.13.  The T-tube is introduced by Desjardin forceps.

FIGURE 36A.14.  The choledochotomy closure is begun above, with the T-tube emerging at the lower end of the repair.
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POSTOPERATIVE MANAGEMENT. Initially, bile is allowed to drain freely into a bile bag to allow any spasm or edema of the sphincter to settle before testing the suture line of the choledochotomy. The volume drained externally should decrease as the bile flow through the ampulla improves. Persistently elevated volume of externally drained bile should raise concerns for continued distal obstruction or to the distal T-tube limb lying within the duodenum. Similarly, there is a problem if there is no external drainage of the bile or if bile drains around the T-tube, and may indicate that the tube is blocked or dislodged from the duct. Issues with T-tube drainage should be evaluated by T-tube cholangiography. If cholangiography does not reveal any issues, management is aimed at waiting for the bile to flow easily through the papilla into the duodenum. The T-tube should be left to external gravity drainage until this occurs. Once it appears that bile is flowing into the duodenum, a T-tube cholangiogram can be taken about 5 to 7 days postoperatively. If it appears normal, the tube is removed on day 7 or 8 by gentle traction.

If there are residual stones or unclear findings on T-tube cholangiography in the first 1 to 2 weeks after surgery, intervention does not necessarily need to be undertaken unless the patient has signs of cholangitis or rising bilirubin. A repeat cholangiogram several days later will often show spontaneous passage of the stone. If a stone is still seen in an otherwise well patient, the patient can safely be sent home with a sealed drainage system and instructions to open the drain to a bag in the event of any problems. After about 5 weeks, further cholangiography is carried out. If the stone is still present, it is extracted via interventional radiology or endoscopic papillotomy (Fig. 36A.17).

**Transduodenal Sphincteroplasty**

The role of transduodenal sphincteroplasty in the treatment of choledocholithiasis centers predominantly around management of impacted stones at the ampulla. It also has a role in treating patients with anatomy that prevents ES (e.g., Billroth II gastrectomy), failures of ES, and sometimes in patients with pancreatitis where a drainage procedure of the duct of Wirsung is indicated (Lehman & Sherman, 1998). Similarly, hydatid cyst remnants and membranes can be readily extracted from the CBD. Exploration may extend to the left and right hepatic ducts, and angled Randall forceps are useful for this purpose.

Sphincteroplasty consists of suturing the outer edge or both edges of a surgical sphincterotomy to avoid possible future stenosis of the incision. The stitches achieve hemostasis of the incision margins and help to avoid possible leakage of the duodenal contents should the excision extend beyond the common portion of the sphincter, incurring the risk of retroduodenal perforation. Transduodenal sphincteroplasty is contraindicated in the presence of a large CBD (>2 cm) or where there is a long
suprasphincteric stricture. It also should not be attempted in the presence of a duodenal diverticulum or where there is severe periampullary inflammation.

**Indications**

The most common indications for transduodenal sphincteroplasty relate to bile duct stones and cholangitis (see Chapter 43).

**STONES IMPACTED IN THE DISTAL AMPULLARY REGION.** An impacted stone is often readily palpable, and the incision may be made safely using the stone as a guide. In such cases, extraction through a supraduodenal cholecototomy is often impossible without undue risk of creating a false passage and without significant risk of postoperative pancreatitis.

**MULTIPLE AND RECURRENT COMMON BILE DUCT STONES.** In cases of multiple and recurrent CBD stones, sphincteroplasty should provide long-term biliary drainage. When 20 or more stones are removed from the CBD, it is probable that one or more stones are still present (Stain et al, 1991). In this situation, choledochoduodenostomy or sphincteroplasty yields excellent results.

**PAPILLARY STENOSIS.** Papillary stenosis is encountered less frequently than in the past. When it is found at operation, transduodenal sphincteroplasty ensures good biliary drainage and prevents restenosis (Ramirez et al, 1994). ES is technically successful in only 60% to 80% of cases, and the mortality rate exceeds 1% (Seifert et al, 1982). In addition, sphincterotomy for papillary stenosis is five times more likely to lead to restenosis than if the same procedure is performed for calculi (Tzovaras & Rowlands, 1998).

**PYOGENIC CHOLANGITIS (SEE CHAPTER 43).** If papillary stenosis or CBD stones or both exist together with cholangitis, transduodenal sphincteroplasty can be an excellent procedure for definitive biliary drainage.

**CHRONIC PANCREATITIS AND ACUTE GALLSTONE PANCREATITIS (SEE CHAPTERS 55 TO 58).** In chronic pancreatitis, some authors report good long-term results with transduodenal sphincteroplasty alone (Hacaim et al, 1994) or in addition to transpapillary septectomy (Moody et al, 1983) or with other drainage procedures of the duct of Wirsung (Kestens et al, 1996). The presence of a stone at the lower end of the CBD or pancreatic duct may cause biliary pancreatitis, and transduodenal sphincteroplasty with clearance of the CBD is a treatment option.

**Technique**

Sphincteroplasty consists of the incision of the common portion of the sphincter of Oddi (Fig. 36A.18) with partial suture of the incision margin. Using this procedure, the sphincters of the CBD and the duct of Wirsung are not involved, and their functions are not impaired. The procedure also can be called a subtotal lower sphincteroplasty (Fig. 36A.19) (Stefanini et al, 1977). The approach to the sphincter of Oddi is through a minimal duodenotomy in the second part of the duodenum.

**Preparation, Position of the Patient, and Incision**

Preoperative preparation is routine. The patient is placed in a supine position on a radiotransparent operating table. A transverse incision below the right costal margin is preferred (Vogt & Hermann, 1981). This incision allows optimal light and excellent access; it is particularly suitable in obese patients, and the incidence of postoperative incisional hernia is probably lower than with vertical and oblique incisions. The incision of
the abdominal wall follows a transverse line, from the midaxillary to the median line at the level of the 11th and 12th ribs (Fig. 36A.20).

**Preparation of the Operative Field and Exposure**

The abdomen is opened, and a large retractor is positioned at the upper margin of the wound. The hepatic flexure of the colon is displaced inferiorly, and the stomach is displaced to the left by means of two surgical pads. Viscera are maintained in this position with two large, curved Deaver retractors. For the performance of the sphincteroplasty, extended mobilization of the duodenum and pancreas (Kocher maneuver) is mandatory (Moody et al, 1983). The assistant surgeon displaces the second portion medially and forward, and the peritoneum is incised posteriorly along the curved lateral margin of the duodenum. The mesocolon of the right colic flexure is cleared inferiorly. At this point, the assistant surgeon also should displace the duodenum superiorly (Fig. 36A.21). Access is provided to the avascular space between the posterior aspect of the head of the pancreas anteriorly and the perinephric fat and inferior vena cava posteriorly; elevation of the structures should reach the left margin of the inferior vena cava. It is important to expose and mobilize the third portion of the duodenum to allow easy access to the papilla and for closure of the duodenotomy without tension (see Fig. 36A.21).

**Duodenotomy**

Duodenotomy is performed in the lateral duodenal wall by surgical diathermy. The cut is 10 to 15 mm long immediately above the inferior knee of the duodenum, with the surgeon taking account of the fact that the papilla usually is located at...
the junction of the lower third with the upper two thirds of the second portion of the duodenum (Fig. 36A.22). The duodenal incision may be longitudinal or transverse; both types are suitable, provided that the suture of such incisions is always transverse. We prefer a longitudinal incision, because if the retractor on the duodenum widens the duodenotomy, this occurs longitudinally. In the case of a transverse duodenotomy, any inadvertent extension would cause a transverse enlargement of the wound.

**Identification of the Papilla**

After the duodenal incision, the papilla is readily shown on the medial duodenal wall in 15% to 20% of patients. It appears as a roundish elevation with a central orifice. If the papilla is not readily visible, it should be detected by displacement and flattening of the mucosal folds. Identification of the papilla under direct vision is possible in 80% of patients. If this is not the case, digital palpation can be used running the forefinger, introduced through the duodenotomy, across the medial duodenal wall. The papilla is identified as a small elevation. If digital palpation fails, a small (5 to 6 Fr) Nélaton catheter can be introduced via the cystic duct stump and advanced downward to emerge at the papilla (Fig. 36A.23). This maneuver should never be performed with rigid catheters because this may result in the formation of false passages.

Sometimes a very small papilla is detected, and its catheterization is difficult or impossible. In such cases, the orifice is probably that of the duct of Santorini. The major papilla should be searched for in a lower position.

**Sphincteroplasty**

After the papilla has been identified, it is exposed by gentle extraction with an Allis or similar clamp. This clamp is applied laterally, never medially, to avoid trauma to the duct of Wirsung. After the papilla has been identified, it is exposed by gentle extraction with an Allis or similar clamp. This clamp is applied laterally, never medially, to avoid trauma to the duct of Wirsung. After the papilla has been identified, it is exposed by gentle extraction with an Allis or similar clamp. This clamp is applied laterally, never medially, to avoid trauma to the duct of Wirsung.

**Instrumental Exploration of the Common Bile Duct**

After sphincteroplasty, instrumental exploration of the CBD and extraction of stones is performed (Speranza et al, 1982). An angled Randall forceps is introduced into the CBD, and the bile duct is carefully explored. The maneuver should be repeated several times to extract all stones. The next step is to rinse with saline solution, introduced under slight pressure with a Nélaton catheter (8 to 9 Fr) and abruptly withdrawn so that small fragments flow downstream with the siphoning (Fig. 36A.24) (Partington, 1977). A Nélaton catheter (4 to 5 Fr) is introduced from the outside or via the cystic duct. Following the line of the catheter—and avoiding plastic catheters, which melt when surgical diathermy is applied—the surgeon makes a cut using surgical diathermy. This cut is made superiorly (at the 11 o’clock position) for 4 to 5 mm (Fig. 36A.25). We prefer surgical diathermy because the instrument ensures good hemostasis. When a sample for biopsy is required, it should be obtained with a scalpel and be taken only from the outer margin of the incision. Possible bleeding from the cut, usually modest, can be arrested with a stitch. After sphincterotomy, two or three stitches are placed between the duodenal mucosa and the wall of the CBD on the outer margin by using an atraumatic needle and fine sutures. Traction is applied to these sutures, and incision of the sphincter is extended for another 6 to 7 mm with sutures placed every 2 to 3 mm, all laterally, until the entire common tract of the sphincter of Oddi has been incised (Fig. 36A.26). The incision is complete when it is 10 to 12 mm long and an appropriate forceps can be easily introduced (Fig. 36A.27). Its entry into the CBD allows an abundant flow of bile owing to distension of its sphincter. Sutures should be placed only on the outer margin of the sphincterotomy to prevent the risk of damage to the duct of Wirsung. The opening of the duct of Wirsung usually is identified as a small orifice from which clear, colorless pancreatic juice flows.
FIGURE 36A.24. The duodenotomy is kept open by a suitable retractor placed in the upper margin of the duodenal incision. The papilla is exposed by gentle traction with an Allis clamp placed laterally, never medially, to avoid trauma to the duct of Wirsung.

FIGURE 36A.25. With a Nélaton catheter as a guide, a cut is made using surgical diathermy on the medial wall of the duodenum extending superiorly and slightly externally (11 o’clock position). With diathermy, good hemostasis is achieved.

FIGURE 36A.26. After sphincterectomy is performed, several stitches are placed between the duodenal mucosa and the wall of the common bile duct (CBD) by using an atraumatic needle and 3-0 suture. Sutures should be placed only on the outer margin of the sphincterotomy to avoid the risk of damaging the duct of Wirsung, which in its distal portion runs inferiorly and medially along the length of the CBD.

FIGURE 36A.27. Sphincteroplasty is completed when the incision is 10 to 21 mm long, and a Randall forceps can be introduced easily into the common bile duct to extract stones or other foreign bodies.
Other means to extract stones from the CBD are with a Fogarty catheter and Dormia basket. The problem of residual stones is best prevented with cholangioscopy; the endoscope is introduced via the sphincteroplasty.

**Duodenal Closure**

As already emphasized, initial longitudinal duodenotomy always should be closed transversely to avoid stenosis of the duodenum. First, the superior and inferior margins of the incisions are approximated, and the resulting gaps are sutured with two extramucosal, nonabsorbable purse-string sutures. Three or four nonabsorbable seromuscular sutures are added (Fig. 36A.29). The suture should not be under tension, and for this reason, preliminary extended mobilization of the duodenum and pancreas is mandatory. The operation is now complete, and the wound is closed without abdominal drains.

**Comment**

It is not necessary to perform transduodenal sphincteroplasty combined with supraduodenal choledochotomy, which has a higher associated mortality rate (Scheridan et al, 1987). The cystic duct remnant may be used to introduce a Nélaton catheter to assist recognition of the papilla. There is no need to insert a T-tube, which lengthens the hospital stay and may predispose the patient to stenosis and infection of the CBD (Ratych et al, 1991; Scheridan et al, 1987).

**Review of Reported Results**

In a retrospective analysis of 25,541 transduodenal sphincteroplasties performed by 130 surgeons in different countries, early transduodenal sphincteroplasty–related complications were bleeding (0.65%), acute pancreatitis (0.60%), dehiscence of the duodenal closure (0.55%), and cholangitis (0.50%), for an overall morbidity rate of 2.3% and a mortality rate of 0.8% (Negro et al, 1984). A retrospective study (Sellner et al, 1988) found that the factors affecting mortality in 2.1% of 333 patients could be avoided by performing the procedure under general anesthesia and by using a transduodenal sphincteroplasty technique.
(but only in 0.9% for sphincterectomy-related complications) were age older than 70 years and a bilirubin level greater than 85 mmol/L, diabetes, renal failure, and coagulopathy. The mortality rate increased when supraduodenal choledochotomy was combined with transduodenal sphincteroplasty and when a T-tube was used (Sellner et al, 1988). Transduodenal sphincteroplasty alone (Hacain et al, 1994) or associated with transampullary septectomy (Kelly & Rowlands, 1996) has led to good long-term results in patients with chronic and acute recurrent pancreatitis, even in cases with pancreas divisum and in selected patients with abdominal pain of hepatobiliary origin.

References are available at expertconsult.com.
REFERENCES


