CHOLECYSTECTOMY AND COMMON BILE DUCT EXPLORATION


Cholecystectomy is the treatment of choice for symptomatic gallstones because it removes the organ that contributes to both the formation of gallstones and the complications ensuing from them. The morbidity associated with cholecystectomy is attributable to injury to the abdominal wall in the process of gaining access to the gallbladder (i.e., the incision in the abdominal wall and its closure) or to inadvertent injury to surrounding structures during dissection of the gallbladder. Efforts to diminish the morbidity of open cholecystectomy have led to the development of laparoscopic cholecystectomy, made possible by modern optics and video technology.

Carl Langenbuch performed the first cholecystectomy in Berlin, Germany, in 1882. Erich Mühe performed the first laparoscopic cholecystectomy in Germany in 1985, and by 1992, 90% of cholecystectomies in the United States were being performed laparoscopically. Compared with open cholecystectomy, the laparoscopic approach has dramatically reduced hospital stay, postoperative pain, and convalescent time. However, rapid adoption of laparoscopic cholecystectomy as the so-called gold standard for treatment of symptomatic gallstone disease was associated with complications, including an increased incidence of major bile duct injuries. Since the early 1990s, considerable advances have been made in instrumentation and equipment, and a great deal of experience with laparoscopic cholecystectomy has been amassed worldwide. Of particular significance is the miniaturization and improvement of optics and instruments, which has reduced the morbidity of the procedure by making possible ever-smaller incisions. With proper patient selection and preparation, laparoscopic cholecystectomy is being safely performed on an outpatient basis in many centers.4

The primary goal of cholecystectomy is removal of the gallbladder with minimal risk of injury to the bile ducts and surrounding structures. Our approach is designed to maximize the safety of both routine and complicated cholecystectomies. In what follows, we describe our approach and discuss current indications and techniques for imaging and exploring the common bile duct (CBD).

Laparoscopic Cholecystectomy

PREOPERATIVE EVALUATION

To plan the surgical procedure, assess the likelihood of conversion to open cholecystectomy, and determine which patients are at high risk for CBD stones, the surgeon must obtain certain data preoperatively. Useful information can be obtained from the patient’s history, from imaging studies, and from laboratory tests.

**History and physical examination** A good medical history provides information about associated medical problems that may affect the patient’s tolerance of pneumoperitoneum. Patients with cardiorespiratory disease may have difficulty with the effects of CO2 pneumoperitoneum on cardiac output, lung inflation pressure, acid-base balance, and the ability of the lungs to eliminate CO2. Most bleeding disorders can also be identified through the history. A disease-specific history is important in identifying patients in whom previous episodes of acute cholecystitis may make laparoscopic cholecystectomy more difficult, as well as those at increased risk for choledocholithiasis (e.g., those who have had jaundice, pancreatitis, or cholangitis).4-9

Physical examination identifies patients whose body habitus is likely to make laparoscopic cholecystectomy difficult and is helpful for determining optimal trocar placement. Abdominal examination also reveals any scars, stomas, or hernias that are likely to necessitate the use of special techniques for trocar insertion.

**Imaging studies** Ultrasonography is highly operator dependent, but in capable hands, it can provide useful information. It is the best test for diagnosing cholelithiasis, and it can usually determine the size and number of stones.4 Large stones indicate that a larger incision in the skin and the fascia will be necessary to retrieve the gallbladder. Multiple small stones suggest that the patient is more likely to require operative cholangiography (if a policy of selective cholangiography is practiced) [see Operative Technique, Step 5, below]. A shrunken gallbladder, a thickened gallbladder wall, and pericholecystic fluid on ultrasonographic examination are significant predictors of conversion to open cholecystectomy. The presence of a dilated CBD or CBD stones preoperatively is predictive of choledocholithiasis. Other intraabdominal pathologic conditions, either related to or separate from the hepatic-biliary-pancreatic system, may influence operative planning.

Preoperative imaging studies of the CBD may allow the surgeon to identify patients with CBD stones before operation. Such imaging may involve endoscopic retrograde cholangiopancreatography (ERCP) [see 5:18 Gastrointestinal Endoscopy],10 magnetic resonance cholangiopancreatography (MRCP) [see Figure 1],11,12 or ultrasonographic examination (EUS). These imaging modalities also provide an anatomic map of the extrahepatic biliary tree, identifying unusual anatomy preoperatively and helping the surgeon plan a safe operation. Endoscopic sphincterotomy (ES) is performed during ERCP if stones are identified in the CBD. MRCP has an advantage over ERCP and EUS in that it is noninvasive and does not make use of injected iodinated contrast solutions.11 Most surgeons would probably recommend that preoperative cholangiography be performed selectively in patients with clinical or biochemical features associated with a high risk of choledocholithiasis. The specific modality used in such a case varies with the technology and expertise available locally.

**Laboratory tests** Preoperative blood tests should include...
liver function, renal function, electrolyte, and coagulation studies. Abnormal liver function test results may reflect choledocholithiasis or primary hepatic dysfunction.

Selection of Patients

Patients eligible for outpatient cholecystectomy Patients in good general health who have a reasonable amount of support from family or friends and who do not live too far away from adequate medical facilities are eligible for outpatient cholecystectomy, especially if they are at low risk for conversion to laparotomy [see Special Problems, Conversion to Laparotomy, below]. These patients can generally be discharged home from the recovery room 6 to 12 hours after surgery, provided that the operation went smoothly, their vital signs are stable, they are able to void, they can manage at least a liquid diet without vomiting, and their pain can be controlled with oral analgesics.

Technically challenging patients Before performing laparoscopic cholecystectomy, the surgeon can predict which patients are likely to be technically challenging. These include patients who have a particularly unsuitable body habitus, those who are highly likely to have multiple and dense peritoneal adhesions, and those who are likely to have distorted anatomy in the region of the gallbladder.

Morbidly obese patients present specific difficulties [see Operative Technique, Step 1, Special Considerations in Obese Patients, below]. Small, muscular patients have a noncompliant abdominal wall, resulting in a small working space in the abdomen and necessitating high inflation pressures to obtain reasonable exposure.

Patients with a history of multiple abdominal operations, especially in the upper abdomen, and those who have a history of peritonitis are likely to pose difficulties because of peritoneal adhesions. These adhesions make access to the abdomen more risky and exposure of the gallbladder more difficult. Patients who have undergone gastroduodenal surgery, those who have any history of acute cholecystitis, those who have a long history of recurrent gall-bladder attacks, and those who have recently had severe pancreatitis are particularly difficult candidates for laparoscopic cholecystectomy. These patients may have dense adhesions in the region of the gallbladder, the anatomy may be distorted, the cystic duct may be foreshortened, and the CBD may be very closely and densely adherent to the gallbladder. Such patients are a challenge to the most experienced laparoscopic surgeon. When such problems are encountered, conversion to open cholecystectomy should be considered early in the operation.

Predictors of choledocholithiasis CBD stones may be discovered preoperatively, intraoperatively, or postoperatively. The surgeon’s goal is to clear the ducts but to use the smallest number of procedures with the lowest risk of morbidity. Thus, before elective laparoscopic cholecystectomy, it is desirable to classify patients into one of three groups: high risk (those who have clinical jaundice or cholangitis, visible choledocholithiasis, or a dilated CBD on ultrasonography), moderate risk (those who have hyperbilirubinemia, elevated alkaline phosphatase levels, pancreatitis, or multiple small gallstones), and low risk.

In our institution, where MRCP and EUS are available and reliable and where ERCP achieves stone clearance rates higher than 90%, we recommend the following approach: (1) preoperative ERCP and sphincterotomy (if required) for high-risk patients and (2) MRCP, EUS, or intraoperative fluoroscopic cholangiography for moderate-risk patients. Patients at low risk for CBD stones do not routinely undergo cholangiography [see Figure 2]. Laparoscopic CBD exploration and postoperative ERCP appear to be equally effective in clearing stones from the CBD.

Ultimately, surgeons and institutions must establish a reasonable approach to choledocholithiasis that takes into account the expertise and equipment locally available.

Contraindications There are few absolute contraindications to laparoscopic cholecystectomy. Certainly, no patient who poses an unacceptable risk for open cholecystectomy should be...
considered for laparoscopic cholecystectomy, because it is always possible that conversion will become necessary. Of the relative contraindications, surgical inexperience is the most important.

Neither ascites nor hernia is a contraindication to laparoscopic cholecystectomy. Ascites can be drained and the gallbladder visualized. Large hernias may present a problem, however, because with insufflation, the gas preferentially fills the hernia. Patients with large inguinal hernias may require an external support to minimize this problem and the discomfort related to pneumoperitoneum. Patients with umbilical hernias can have their hernias repaired while they are undergoing laparoscopic cholecystectomy. For such patients, the initial trocar should be placed by open insertion according to the Hasson technique [see Operative Technique, Step 1, below], with care taken to avoid injury to the contents of the hernia. The sutures required to close the hernia defect can be placed before insertion of the initial trocar. A similar technique can be applied to patients with incisional hernias, although for large incisional hernias, laparoscopic cholecystectomy may have no advantages over open cholecystectomy if a large incision and dissection of adhesions are required. Patients with stomas may also undergo laparoscopic cholecystectomy, provided that the appropriate steps are taken to prevent injury to the bowel during placement of trocars and division of adhesions.

Patients with cirrhosis or portal hypertension are at high risk for morbidity and mortality with open cholecystectomy. If absolutely necessary, laparoscopic cholecystectomy may be attempted by an experienced surgeon. The risk of bleeding can be minimized by rigorous preoperative preparation, meticulous dissection with the help of magnification available through the laparoscope, and use of the electrocautery.

Patients with bleeding diatheses, such as hemophilia, von Willebrand disease, and thrombocytopenia, may undergo laparoscopic cholecystectomy. They require appropriate preoperative and postoperative care and monitoring, and a hematologist should be consulted.

Questions have been raised about whether laparoscopic cholecystectomy should be performed in pregnant patients; it has been argued that the increased intra-abdominal pressure may pose a risk to the fetus. Because of the enlarged uterus, open insertion of the initial trocar is mandatory, and the positioning of other trocars may have to be modified according to the position of the uterus. Inflation pressures should be kept as low as possible, and prophylaxis of deep vein thrombosis (DVT) is recommended. Despite these potential problems, safe performance of laparoscopic cholecystectomy and other laparoscopic procedures in pregnant patients is increasingly being described in the literature. If cholecystectomy is necessary before delivery, the second trimester is the best time for it.18-21

Patients in whom preoperative imaging gives rise to a strong suspicion of gallbladder cancer should probably undergo open surgical management.

OPERATIVE PLANNING

Antibiotic Prophylaxis

Some surgeons recommend routine preoperative administration of antibiotics to all patients undergoing cholecystectomy, on the grounds that inadvertent entry into the gallbladder is not uncommon and can lead to spillage of bile or stones into the peritoneal cavity. Other surgeons do not recommend routine prophylaxis. Resolution of this controversy awaits appropriate prospective trials. We recommend selective use of antibiotic prophylaxis for patients at highest risk for bacteria in the bile (including those with acute cholecystitis or CBD stones, those who have previously undergone instrumentation of the biliary tree, and those older than 70 years) and for patients with prosthetic heart valves and joint prostheses.

Prophylaxis of DVT

The reverse Trendelenburg position used during laparoscopic cholecystectomy, coupled with the positive intra-abdominal pressure generated by CO2 pneumoperitoneum and the vasodilatation induced by general anesthesia, leads to venous pooling in the lower extremities. This consequence may be minimized by using antiem-

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**Operative Technique**

**Algorithm for Preoperative Cholangiography**

*Patient is identified preoperatively as being at moderate or high risk for CBD stones*

Perform preoperative cholangiography.

Stones are detected

Intraoperative CBD exploration (open or laparoscopic) is planned

**Exploration is successful**

Continue with laparoscopic cholecystectomy.

**Exploration is unsuccessful**

Perform postoperative ERCP/ES.

Intraoperative CBD exploration (open or laparoscopic) is not planned

Perform ERCP with ES.

**ERCP/ES is unsuccessful**

Perform cholecystectomy and intraoperative CBD exploration (open or laparoscopic).

**ERCP/ES is successful**

Proceed to laparoscopic cholecystectomy.

*Figure 2* Laparoscopic cholecystectomy. Shown is an algorithm outlining the use of preoperative cholangiography in patients at moderate or high risk for CBD stones.
bolic stockings or by wrapping the legs with elastic bandages. Subcutaneous heparin and pneumatic compression devices may be employed for patients at increased risk for DVT [see Venous Thromboembolism]. As yet, however, there is no convincing evidence that the incidence of DVT is higher with laparoscopy than with open surgery.

**Patient Positioning**

In North American positioning, the patient is lying supine and the surgeon is positioned on the patient's left side [see Figure 3a]. In European positioning, the patient is in low stirrups and the surgeon is on the patient's left or between the patient's legs [see Figure 3b].

With North American positioning, the camera operator usually stands on the patient's left and to the left of the surgeon, while the assistant stands on the patient's right. The video monitor is positioned on the patient's right above the level of the costal margin. If a second monitor is available, it should be positioned on the patient's left to the right of the surgeon, where the assistant can have an unobstructed and comfortable view. Exposure can be improved by tilting the patient in the reverse Trendelenburg position and rotating the table with the patient's right side up. Gravity pulls the duodenum, the colon, and the omentum away from the gallbladder, thereby increasing the working space available in the upper abdomen.

The OR table should allow easy access for a fluoroscopic C arm, to facilitate intraoperative cholangiography. The table cover should be radiolucent.

**Equipment**

The equipment required for laparoscopic cholecystectomy includes an optical system, an electronic insufflator, trocars (cannulas), surgical instruments, and hemostatic devices [see Table 1].

**Optical system** The laparoscope can provide either a straight, end-on (0°) view or an angled (30° or 45°) view. Scopes that provide an end-on view are easier to learn to use, but angled scopes are more versatile. Scopes with a 30° angle cause less disorientation than those with a 45° angle and are ideal for laparoscopic cholecystectomy. Excellent 30° scopes are currently available in diameters of 10 mm, 5 mm, and 3.5 mm.

Fully digital flat-panel displays are now available that yield better resolution than analog video monitors, take up less space, are less subject to signal interference, and require less power. The resolution and quality of the final image depend on (1) the brightness of the light source; (2) the integrity of the fiberoptic cord used to convey the light; (3) clean and secure connections between the light source and the scope; (4) the quality of the laparoscope, the camera, and the monitor; and (5) correct wiring of the components. The distal end of the scope must be kept clean and free of condensation: bile, blood, or fat will reduce brightness and distort the image. Lens fogging can be prevented by immersion in heated water or by antifogging solutions.

**Insufflator** CO₂ is the preferred insufflating gas for laparoscopic procedures because it is highly soluble in water and it does not support combustion when the electrocautery is used. The CO₂ should be insufflated with an electronic pump capable of a flow rate of at least 6 L/min; most current systems have a maximum flow rate of 20 L/min or higher. The insufflator is connected to one of the trocars by means of a flexible tube and a stopcock.

**Trocars** For cholecystectomy, at least one trocar site must be large enough to allow passage of the gallbladder and any stones removed. Most surgeons prefer to use a 10/12 mm trocar at the umbilicus for this purpose. The other trocars can range from 2 to 12 mm, depending on the size of the instruments to be placed through them. The conventional approach is to use a 10/12 mm
trocar at the operating port site and 5 mm trocars for the other instruments; however, if a 5 mm laparoscope and a 5 mm clip applicer are used, the operating port size can be reduced to 5 mm. Although 2 mm instrumentation is also available, it must be remembered that as a rule, the smaller the working port, the less versatile the instruments. In our experience, the combination of a 10 mm umbilical trocar, a 5 mm operating port, and 2 mm ports for grasping forceps is a good one: optical quality is maintained, little flexibility is lost with respect to selecting operating instruments, trocar size is minimized, and the cosmetic result is excellent.

**Hemostatic devices** Hemostasis can be achieved with monopolar or bipolar electrocauterization. A monopolar electrocautery can be connected to most available instruments; however, bipolar electrocauterization may eventually prove safer. With a monopolar electrocautery, depth of burn is less predictable, current can be conducted through noninsulated instruments and trocars, and any area of the instrument that is stripped of insulation may conduct current and result in a burn. Caution is essential when the electrocautery is used near metallic hemostatic clips because delayed sloughing may occur.

Electrocauterization should be avoided near the CBD because delayed bile duct injuries and leaks may occur as a result of sloughing from a burned area and devascularization of the duct. Care must be exercised when a cautery is employed near the bowel and when intra-abdominal adhesions are being taken down. The electrocautery can be used with a forceps, scissors, hooks (L or J shaped), a spatula, and other instruments. Some cautery probes incorporate nonstick surfaces to prevent buildup of eschar. The use of hand-activated cautery probes and the presence of a channel that allows suction and irrigation through the cautery probes are especially convenient.

More advanced energy sources and instruments are also available. Bipolar devices designed to weld tissues have proved capable

### Table 1 Equipment for Laparoscopic Cholecystectomy

<table>
<thead>
<tr>
<th>Instrument/Device</th>
<th>Number</th>
<th>Size</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laparoscopic cart</td>
<td>Laparoscopic cart</td>
<td>1</td>
<td>3.5–10 mm</td>
</tr>
<tr>
<td>High-intensity halogen light source (150–300 watts)</td>
<td>1</td>
<td>3.5–10 mm</td>
<td>Available in 0° and angled views; we prefer to use a 30° 5 mm diameter laparoscope</td>
</tr>
<tr>
<td>High-flow electronic insufflator (minimum flow rate of 6 L/min)</td>
<td>1</td>
<td>3.5–10 mm</td>
<td>Available in 0° and angled views; we prefer to use a 30° 5 mm diameter laparoscope</td>
</tr>
<tr>
<td>Laparoscopic camera box</td>
<td>1</td>
<td>3.5–10 mm</td>
<td>Available in 0° and angled views; we prefer to use a 30° 5 mm diameter laparoscope</td>
</tr>
<tr>
<td>Videocassette recorder (optional)</td>
<td>1</td>
<td>3.5–10 mm</td>
<td>Available in 0° and angled views; we prefer to use a 30° 5 mm diameter laparoscope</td>
</tr>
<tr>
<td>Digital still image capture system (optional)</td>
<td>1</td>
<td>3.5–10 mm</td>
<td>Available in 0° and angled views; we prefer to use a 30° 5 mm diameter laparoscope</td>
</tr>
<tr>
<td>Laparoscope</td>
<td>1</td>
<td>3.5–10 mm</td>
<td>Available in 0° and angled views; we prefer to use a 30° 5 mm diameter laparoscope</td>
</tr>
<tr>
<td>Atraumatic grasping forceps</td>
<td>2–4</td>
<td>2–10 mm</td>
<td>Selection of graspers should allow surgeon choice appropriate to thickness and consistency of gallbladder wall; insulation is unnecessary</td>
</tr>
<tr>
<td>Large-tooth grasping forceps</td>
<td>1</td>
<td>10 mm</td>
<td>Used to extract gallbladder at end of procedure</td>
</tr>
<tr>
<td>Curved dissector</td>
<td>1</td>
<td>2–5 mm</td>
<td>Should have a rotatable shaft; insulation is required</td>
</tr>
<tr>
<td>Scissors</td>
<td>2–3</td>
<td>2–5 mm</td>
<td>One curved and one straight scissors with rotating shaft and insulation; additional microscissors may be helpful for incising cystic duct</td>
</tr>
<tr>
<td>Clip applicers</td>
<td>1–2</td>
<td>5–10 mm</td>
<td>Either disposable multiple clip applicer or 2 manually loaded reusable single clip applicers for small and medium-to-large clips</td>
</tr>
<tr>
<td>Dissecting electrocautery hook or spatula</td>
<td>1</td>
<td>5 mm</td>
<td>Available in various shapes according to surgeon’s preference; instrument should have channel for suction and irrigation controlled by trumpet valve(s); insulation required</td>
</tr>
<tr>
<td>High-frequency electrical cord</td>
<td>1</td>
<td>5–10 mm</td>
<td>Cord should be designed with appropriate connectors for electrosurgical unit and instruments being used</td>
</tr>
<tr>
<td>Suction-irrigation probe</td>
<td>1</td>
<td>5–10 mm</td>
<td>Probe should have trumpet valve controls for suction and irrigation; may be used with pump for hydrodissection</td>
</tr>
<tr>
<td>10–to–5 mm reducers</td>
<td>2</td>
<td>5–10 mm</td>
<td>Allow use of 5 mm instruments in 10 mm trocar without loss of pneumoperitoneum; these are often unnecessary with newer disposable trocars and may be built into some reusable trocars</td>
</tr>
<tr>
<td>5–to–3 mm reducer</td>
<td>1</td>
<td>5–10 mm</td>
<td>Allows use of 2–3 mm instruments and ligating loops in 5 mm trocars</td>
</tr>
<tr>
<td>Ligating loops</td>
<td>Endoscopic needle holders</td>
<td>1–2</td>
<td>5 mm</td>
</tr>
<tr>
<td>Cholangiogram clamp with catheter</td>
<td>1</td>
<td>5 mm</td>
<td>Allows passage of catheter and clamping of catheter in cystic duct</td>
</tr>
<tr>
<td>Veress needle</td>
<td>1</td>
<td>5 mm</td>
<td>Used if initial trocar is inserted by percutaneous technique</td>
</tr>
<tr>
<td>Allis or Babcock forceps</td>
<td>1–2</td>
<td>5 mm</td>
<td>Allow atraumatic grasping of bowel or gallbladder</td>
</tr>
<tr>
<td>Long spinal needle</td>
<td>1</td>
<td>14-gauge</td>
<td>Useful for aspirating gallbladder percutaneously in cases of acute cholecystitis or hydrops</td>
</tr>
<tr>
<td>Retrieval bag</td>
<td>1</td>
<td>5 mm</td>
<td>Useful for preventing spillage of bile or stones in removal of inflamed or friable gallbladder; facilitates retrieval of spilled stones</td>
</tr>
</tbody>
</table>
The laparoscope is inserted through this trocar and um or in the right anterior axillary line, where bowel adhesions are peritoneum in most cases. A trocar potentially hazardous, particularly when the percutaneous surface of the abdominal wall make access to the abdominal cavity potentially hazardous, particularly when the percutaneous method is used for placement of the initial trocar. Scars from previous operations may affect insertion of the initial trocar, depending on its orientation and location. If a patient has a scar in the lower abdomen (e.g., from a Pfannenstiel incision or an incision in the right lower quadrant for an appendectomy), the position of the initial trocar need not be changed. If the scar is in the upper abdomen, the initial trocar may be inserted below the umbilicus in the midline. If there is a long midline scar that is impossible to avoid, careful dissection of the peritoneum through a vertical incision that is somewhat longer than usual affords safe access to the peritoneum in most cases.

An alternative is to insert the initial trocar high in the epigastrium or in the right anterior axillary line, where bowel adhesions are less common. The laparoscope is inserted through this trocar and used to examine the undersurface of the old scar for a clear site near the umbilicus where a 10 mm trocar can be placed. Previous laparoscopy, which rarely creates significant intra-abdominal adhesions, rarely necessitates modification of trocar insertion.

The surgeon should also consider the reason for the previous surgery. For example, a patient who underwent an appendectomy for perforating appendicitis may have had diffuse peritonitis and may have adhesions well away from the old scar.

**Operative Technique**

**Step 1: Placement of Trocars and Accessory Ports**

**Placement of initial trocar** The first step in laparoscopic cholecystectomy is the creation of pneumoperitoneum and the insertion of an initial trocar through which the laparoscope can be passed. This step is critical because complications resulting from improper placement may cause serious morbidity and death. The surgeon may use either a percutaneous technique or an open technique. We prefer the open technique, which eliminates the risks inherent in the blind puncture.

**Scars** Patients who have previously undergone abdominal surgery may have adhesions, both to the undersurface of the abdominal wall and intra-abdominally. Adhesions to the undersurface of the abdominal wall make access to the abdominal cavity hazardous, particularly when the percutaneous method is used for placement of the initial trocar. Scars from previous operations may affect insertion of the initial trocar, depending on its orientation and location. If a patient has a scar in the lower abdomen (e.g., from a Pfannenstiel incision or an incision in the right lower quadrant for an appendectomy), the position of the initial trocar need not be changed. If the scar is in the upper abdomen, the initial trocar may be inserted below the umbilicus in the midline. If there is a long midline scar that is impossible to avoid, careful dissection of the peritoneum through a vertical incision that is somewhat longer than usual affords safe access to the peritoneum in most cases.

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**Placement of accessory ports** In most cases, four ports are necessary. The first port is for the laparoscope; the remaining ports are for grasping forceps, dissectors, and clip applicators. The precise position of the accessory ports depends on the surgeon’s preference, the patient’s body habitus, and the presence or absence of previous scars or intra-abdominal adhesions. A rigid approach to port placement is inappropriate: trocar placement determines operative exposure, and improper placement will haunt the surgeon throughout the procedure. In some cases, a fifth trocar is required to elevate a floppy liver or to depress or retract the omentum or a bulky hepatic flexure of the colon. In trocar placement, as in patient positioning, European practice tends to differ from North American practice.

Most surgeons elect to place one of the grasping forceps on the fundus of the gallbladder through an accessory port placed approximately in the anterior axillary line below the level of the gallbladder. Because the level of the gallbladder varies from patient to patient, the placement of this accessory port should not be decided on until the gallbladder is visualized. If the gallbladder is low lying and the trocar is placed too high, the surgeon will have difficulty achieving the appropriate angle of retraction. As a general rule, positioning the trocar in the anterior axillary line approximately halfway between the costal margin and the anterosuperior iliac spine provides the appropriate exposure. A 2 to 5 mm port usually suffices at this site because its only likely function is to allow retraction of the gallbladder. In some cases of acute cholecystitis, however, a larger port may be preferable, so that a larger grasper.
can be inserted and used to hold the gallbladder without tearing it.

A second accessory port (also 2 to 5 mm) allows the surgeon to grasp the gallbladder in the area of Hartmann’s pouch for retraction. This port is usually positioned just beneath the right costal margin. Some surgeons prefer it to be approximately at the midclavicular line; others prefer it to be higher and more medial, just to the right of the falciform ligament.

The main operating port should be 5 or 10 mm in diameter, so that clip appliers can be readily placed through it and the laparoscope can be moved to this port at the end of the procedure. The positioning of this port is determined by the surgeon’s preference and, in particular, by the patient’s body habitus. The optimum placement is at about the same horizontal level as the gallbladder or slightly higher, so that during the operation, the laparoscope and the operating instrument form an angle of about 90º. Some surgeons prefer to place the operative port in the midline, to the right of the falciform ligament; others prefer to place it to the left of the falciform, passing the trocar underneath the ligament and elevating it with the trocar.

Surgeons should be encouraged to use both hands when performing laparoscopic cholecystectomy. One hand should control the grasping forceps holding Hartmann’s pouch, so that the gallbladder can be moved to provide the best possible exposure. The other hand should control the dissecting instruments placed through the operating port.

**Special considerations in obese patients**  Port placement in obese patients may be complicated by the thick abdominal wall, the large amount of intra-abdominal fat, or both. A thick abdominal wall makes it more difficult to rotate the trocar around the normal fulcrum point in the abdominal wall. Consequently, the trocar must be placed at the angle most likely to be used during the procedure. When a trocar is tunneled through the abdominal wall, more of the cannula is within the abdominal wall than if the trocar had been placed perpendicularly; accordingly, the trocar is less mobile. If the trocars are not easily rotated, the instruments placed through them will be difficult to manipulate smoothly. Thus, in the patient with a very thick pannus, a standard-length trocar may be too short. Displacement of trocars can lead to insufflation into the abdominal wall and consequently to subcutaneous emphysema, which further thickens the abdominal wall and hinders exposure.

To prevent such problems, special extra-length trocars designed for morbidly obese patients have been developed. It may also be necessary to place the trocars closer to the area of the gallbladder to ensure that the operating instruments can reach the gallbladder. For example, the initial port may have to be placed above the umbilicus.

In obese patients, the bulky falciform ligament and the large omentum may adversely affect exposure. A 30º laparoscope may help the surgeon see over the omentum and the high-lying hepatic flexure of the colon. In some cases, it is useful to place a fifth port so that the surgeon can retract the hepatic flexure downward. Fat may envelop the cystic duct and artery and the portal structures, obscuring normal anatomic landmarks. When the electrocautery is used, the heat melts the fat and causes it to sizzle and spray onto the lens of the laparoscope, resulting in a blurry image. To prevent this, the camera operator should pull the scope slightly away from the operative field during electrosurgery, then advance the scope during dissection. This should also be done when an ultrasonic dissector is being used.

Given that obese patients are more difficult candidates for open cholecystectomy and have a higher complication rate with laparotomy, the advantages of laparoscopic cholecystectomy in these individuals justify the effort needed to overcome the technical problems.

![Figure 5](image)  Laparoscopic cholecystectomy. Illustrated are the differences between typical North American practice (a) and typical European practice (b) with respect to the placement of the trocars and the instruments inserted through each port.
Step 2: Exposure of Gallbladder and Calot’s Triangle

**Dissection of adhesions** Adhesions must be dissected to provide an unimpeded view of the gallbladder through the laparoscope. Not all intra-abdominal adhesions must be taken down, just enough to allow entry of accessory trocars under direct vision and thus permit access to the gallbladder. This process is facilitated by pneumoperitoneum, which provides traction on adhesions to the abdominal wall, and by the magnification provided by the optical system, which allows identification of the avascular plane of attachment.

The most difficult problem is positioning the dissecting instruments so that they can reach the undersurface of the anterior abdominal wall. A rigid trocar inserted through the anterior abdominal wall cannot be rotated enough to allow scissors passed through this port to cut adhesions to the anterior abdominal wall. In such cases, one or two trocars should be placed laterally, near the anterior axillary or midaxillary line. Instruments passed through these ports can easily be angled parallel to the anterior abdominal wall, and the adhesions can then be dissected without difficulty.

Bowel adhesions should be taken down with endoscopic scissors at their insertion to the abdominal wall, where they are least vascular. Electrocauterization, generally unnecessary, should be avoided because of the risk of thermal injury to the bowel. Interloop adhesions, which rarely interfere with exposure of the gallbladder, need not be dissected. Frequently, adhesions to the gallbladder occur as a reaction to inflammatory attacks [see Figure 6]. They are usually relatively avascular. Dissection of these adhesions should begin at the fundus of the gallbladder and should then proceed downward toward the neck of the gallbladder. The best way to take them down is to grasp the gallbladder with one grasping forceps at the site where the adhesions attach and gradually place traction on the adhesions with the other hand. Usually, the adhesions peel down in an avascular plane. Dissection should continue until all adhesions to the inferolateral aspect of the gallbladder have been taken down. It is not necessary to divide adhesions between the superior surface of the liver and the undersurface of the diaphragm unless they impede superior retraction of the liver.

**Exposing Calot’s triangle** Obtaining adequate exposure of Calot’s triangle is a key step. First, the patient is placed in a reverse Trendelenburg position, with the table rotated toward the left side. Next, the fundus of the gallbladder and the right lobe of the liver are elevated toward the patient’s right shoulder. One grasping forceps, inserted through the most lateral right-side port and held by an assistant, is placed on the fundus of the gallbladder [see Figure 7], and the gallbladder is retracted superiorly and laterally above the right hepatic lobe. This maneuver straightens out folds in the body of the gallbladder and permits initial visualization of the area of Calot’s triangle. If Calot’s triangle is still obscured, the patient can be placed in a steeper reverse Trendelenburg position, the stomach can be emptied of air via an orogastric tube inserted by the anesthetist, or, if necessary, a fifth trocar can be inserted on the patient’s right side to push down the duodenum.

In some patients, such as those with acute cholecystitis and hydrops of the gallbladder, the gallbladder is tense and distended, making it difficult to grasp and easy to tear. In these patients, retraction of the fundus is difficult, and exposure of Calot’s triangle is unsatisfactory. This problem is best managed by aspirating the contents of the gallbladder either percutaneously with a 14- or 16-gauge needle inserted into the fundus of the gallbladder under laparoscopic vision or by using the 5 mm trocar in the right upper abdomen to puncture the fundus and then aspirate with the suction irrigator. After the needle is withdrawn, a large atraumatic grasping forceps can be used to hold the gallbladder and occlude the hole; a 10 mm forceps may be preferred if the wall is markedly thickened. An alternative is to place a stitch or a ligating loop around the fundus of the collapsed gallbladder; the tail of the suture can then be grasped with a forceps to achieve a secure grip and also prevent further leakage of gallbladder contents from the needle hole.

Once the fundus of the gallbladder is retracted superiorly by the assistant, the surgeon places a grasping forceps in the area of Hartmann’s pouch. Using both hands, the surgeon controls the grasper on Hartmann’s pouch as well as the operating instrument. The surgeon maneuvers Hartmann’s pouch to provide various angles for safe dissection of Calot’s triangle. Initially, lateral and
inferior traction are placed on Hartmann’s pouch, opening up the angle between the cystic duct and the common ducts [see Figure 8], avoiding their alignment [see Figure 9]. A large stone impacted in the gallbladder neck may impede the surgeon’s ability to place the forceps on Hartmann’s pouch. This problem can usually be managed by dislodging the stone early in the operation, as follows: the gallbladder is grasped as low as possible with one grasping forceps; a widely opening dissecting instrument, such as a right-angle dissector, a Babcock forceps, or a curved dissector, is used to dislodge the stone and milk it up toward the fundus; with the same forceps or another large grasper, the stone is held up and away from the neck of the gallbladder, and appropriate retraction is provided.

If the stone cannot be disimpacted, an instrument can be used to elevate the infundibulum of the gallbladder superiorly, allowing exposure of Calot’s triangle. Alternatively, one can attempt to crush the stone, but small pieces of the stone may fall into the cystic duct. A third option is to place a stitch in Hartmann’s pouch and grasp the end of the stitch to provide exposure.

**Step 3: Stripping of Peritoneum**

The key to avoiding injury to the major ducts during laparoscopic cholecystectomy is accurate identification of the junction between the gallbladder and the cystic duct [see Figure 10]. Unless the gallbladder-cystic duct junction is immediately obvious upon examination of Calot’s triangle anteriorly, our approach is to begin dissection of Calot’s triangle posteriorly [see Figure 11]. From this approach, the insertion of the gallbladder neck into the cystic duct is usually more clearly identified, especially with the aid of a 30º laparoscope. Exposure is obtained by retracting Hartmann’s pouch superomedially and is facilitated by looking from below with a 30º scope.

Dissection should always start high on the gallbladder and hug
the gallbladder closely until the anatomy is identified clearly. Using a curved dissector, the surgeon gently teases away peritoneum attaching the neck of gallbladder to the liver posterolaterally to visualize the funneling of the neck of the gallbladder into the cystic duct [see Figure 12]. Only the posterior layer of peritoneum is dissected; care must be taken not to dissect deeply in this area because of the risk of injury to the cystic artery [see Figure 13].

In some problem cases, edema, fibrosis, and adhesions make identification of the gallbladder–cystic duct junction very difficult. An anatomic landmark on the liver known as Rouvier's sulcus may be helpful in such circumstances [see Figure 11]. This sulcus, or the remnant of it, is present in 70% to 80% of livers and usually contains the right portal triad or its branches. Its location is consistently close to the right of the hepatic hilum and anterior to the caudate process (Couinaud segment 1). This landmark reliably indicates the plane of the CBD. Therefore, dissection dorsal to it should be done with caution. Once the funneling of the gallbladder into the cystic duct has been identified, the area of Hartmann's pouch should be again pulled laterally and inferiorly so that the anterior peritoneum can be dissected, while the 30° scope is angled to view the area. The two-handed technique facilitates the surgeon's movement between the posterior and anterior aspects of Calot's triangle, providing complete visualization. Dissection should always take place at the gallbladder–cystic duct junction, staying close to the gallbladder to avoid inadvertent injury to the CBD. A curved dissecting forceps is used to strip the fibroareolar tissue just superior to the cystic duct. The superior border of the cystic duct can then be identified and the cystic duct gently and gradually dissected [see Figure 14]. The cystic duct lymph node is a useful landmark at this location and may facilitate identification of the gallbladder–cystic duct junction.

When traction is placed as described, the cystic artery tends to run parallel and somewhat cephalad to the cystic duct. This artery can often be identified by noting its close relation to the cystic duct lymph node. Complete dissection of the area between the cystic duct and the artery develops a window through which the liver should be visible. The cystic duct is then incised with a curved dissecting instrument or an L-shaped hook. Downward traction should be applied to the cystic duct to open this window and ensure that there is no ductal structure running through this space in Calot's triangle to join the cystic duct (i.e., the right hepatic duct).

Dissection of Calot's triangle should be completed before the cystic duct is clipped or divided. This is best accomplished by dissecting the neck of the gallbladder from the liver bed. Unequivocal identification of the gallbladder–cystic duct junction is imperative.24,25 The cystic duct should be dissected for a length sufficient to permit secure placement of two clips; it is not necessary, and indeed may be hazardous, to attempt to dissect the cystic duct–CBD junction.

The cystic artery is exposed next [see Figure 15]. A small vein can usually be identified in the space between the cystic duct and the cystic artery; it can usually be pulled up anteriorly and cauterized. Because dissection is done near the gallbladder, it is not unusual to encounter more than one branch of the cystic artery. Each of these branches should be dissected free of the fibroareolar tissue. Care should also be taken to ensure that the right hepatic artery is not inadvertently injured as a result of being mistaken for the cystic artery.

**Step 4: Control and Division of Cystic Duct and Cystic Artery**

At this point, the cystic duct is clipped on the gallbladder side, and a cholangiogram is obtained if desired [see Step 5, below]. If a cholangiogram is not desired, three or four clips should be placed on the cystic duct and the cystic duct divided between them. Two or three hemostatic clips are placed on the cystic artery, and the vessel is divided. It is prudent to incise the artery partially before transecting it completely to ensure that the clips are secure and that there is no pulsatile bleeding. Once the artery is completely divided, the proximal end will retract medially, making it more difficult to expose and control the artery safely if bleeding occurs. Electrocauterization should be avoided near the cystic duct and all metallic clips. Electrical current will be conducted through metallic clips and may result in delayed sloughing of the duct or a clip. Delayed injuries to the CBD may be caused by a direct burn to the duct or by sparking from noninsulated instruments or clips during dissection. An alternative is to use locking polymer clips that fit through 5 mm ports, clip across a greater width of tissue, and do not conduct electricity.

**Control of short or wide cystic duct** Edema and acute inflammation may lead to thickening and foreshortening of the
cystic duct, with subsequent difficulties in dissection and ligation. If the duct is edematous, clips may cut through it; if the duct is too wide, the clip may not occlude it completely. A modified clipping technique can be employed, with placement of an initial clip to occlude as much of the duct as possible. The occluded portion of the duct is then incised, and a second clip is placed flush with the first so as to occlude the rest of the duct. Alternatively, wider polymer clips may be used.

Because this technique is not always possible, the surgeon should be familiar with techniques for ligating the duct with either intracorporeal or extracorporeal ties. It is extremely helpful to know how to tie extracorporeal ties so that the cystic duct can be ligated in continuity before it is divided. In some cases, the duct can be divided, held with forceps, and controlled with a ligating loop. If there is concern about secure closure of the cystic duct, a closed suction drain may be placed. If inflammation, as in cholecystitis, has caused the duct to be shorter than usual, dissection must be kept close to the gallbladder to avoid inadvertent injury to the CBD. A short cystic duct is often associated with acute cholecystitis. Patient blunt dissection with the suction-irrigation device may be the safest technique.

**Cystic duct stones** Stones in the cystic duct may be visualized or felt during laparoscopic cholecystectomy. Every effort should be made to milk them into the gallbladder before applying clips. Placing a clip across a stone may push a fragment of the stone into the CBD and will increase the risk that the clip will become displaced, leading to a bile leak. If the stone cannot be milked into the gallbladder, a small incision can be made in the cystic duct (as is done for cholangiography), and the stone can usually be expressed and retrieved. Given that cystic duct stones are predictive of CBD stones, cholangiography or intraoperative ultrasonography is indicated.

**Step 5: Intraoperative Cholangiography**

Whether intraoperative cholangiography should be performed routinely is still controversial. Advocates believe that this technique enhances understanding of the biliary anatomy, thus reducing the risk of bile duct injury; at present, however, there are no objective data to confirm this impression. Cholangiography is not a substitute for meticulous dissection, and injuries to the CBD can occur before cystic duct dissection reaches the point at which cholangiography can be performed. Catheter-induced injuries and perforations of the biliary tree have been reported, and cholangiograms have been misinterpreted. On the other hand, one of the main advantages of cholangiography is that injuries can be recognized during the operation and promptly repaired. Another advantage of routine cholangiography is that it helps develop the skills required for more complex biliary tract procedures, such as transcystic CBD exploration.

The two methods of laparoscopic cholangiography differ in their technique for introducing the cholangiogram catheter into the cystic duct. In both approaches, a clip is placed at the gallbladder–cystic duct junction and a small incision made in the anterior wall of the cystic duct. In the first technique, a specially designed 5 mm cholangiogram clamp (the Olsen clamp) with a 5 French catheter is inserted via a subcostal trocar. For easy guidance of the catheter into the incision in the cystic duct, the catheter should be parallel, rather than perpendicular, to the cystic duct. This angle is facilitated by placing the subcostal port directly below the cystic duct incision, near the anterior axillary line. A fifth trocar may occasionally be needed if exposure is lost when one of the grasping forceps is removed to allow passage of the cholangiogram clamp. The clamp and the catheter are then brought to the cystic duct under direct vision, and the catheter is steered into the duct [see Figure 16]. The clamp is then closed, holding the catheter in position and sealing the duct to avoid extravasation of dye.

In the second method, the cholangiogram catheter is introduced percutaneously through a 12- to 14-gauge catheter, inserted subcostally as described (see above). The surgeon then grasps the cholangiogram catheter and directs it into the cystic duct. A hemostatic clip is applied to secure the catheter in place. If passage of the catheter into the cystic duct is prevented by Heister’s valve, a guide wire can be passed initially.
If the cystic duct is tiny and cannulation is expected to be difficult or impossible, the gallbladder can be punctured, bile aspirated, and contrast material injected through the gallbladder until the biliary tree is filled. The cannulas and operating instruments should be positioned so as not to obstruct the view of the biliary tree. If the cannulas cannot be positioned outside the x-ray window, radiolucent cannulas should be used, or the cannulas should be removed and replaced after the cholangiogram. A cholangiogram that does not visualize the biliary tree from the liver to the duodenum is inadequate. Fluoroscopic cholangiography [see Figure 17] may be performed either with hard-copy film or with digital imaging and storage. After the C arm is positioned, with the operating staff protected behind a lead screen, full-strength contrast is slowly injected under fluoroscopic control. The goal is to visualize the biliary tree in its entirety, including the right and left hepatic ductal systems as well as the distal duct. Once the cholangiogram is obtained, the catheter is removed, and the cystic duct is double-clipped and transected.

**Laparoscopic ultrasonography** Evaluation of the biliary tree with intraoperative laparoscopic ultrasonography appears to be as accurate as intraoperative fluorocholangiography in identifying biliary stones. This modality has several advantages over conventional cholangiography: it does not expose patients and staff to radiation; contrast agents are unnecessary; there is no need to cannulate the cystic duct; significantly less time is required; the capital cost of most ultrasound units is less than that of fluoroscopic equipment; and disposable cholangiogram catheters are not needed.

Most of the laparoscopic ultrasound devices in use at present are 7.5 MHz linear-array rigid probes 10 mm in diameter. Flexible probes capable of multiple frequencies are also available, and it is likely that future probes will be increasingly versatile. The probe is inserted through a 10/12 mm port (usually a periumbilical or epigastric port) and placed directly on the porta hepatis, perpendicular to the structures of the hepatoduodenal ligament. The probe is then moved to the cystic duct–CBD junction. The transverse image obtained should show the three tubular structures of the hepatoduodenal ligament in the so-called Mickey Mouse head configuration: the CBD, the portal vein, and the hepatic artery [see Figure 18]. As the probe is moved distally, it is rotated clockwise to allow identification of the distal CBD and the pancreatic duct where they unite at the papilla. Instillation of saline into the right upper quadrant can enhance acoustic coupling and improve visualization.

Because of its many advantages, intraoperative laparoscopic ultrasonography may eventually replace fluorocholangiography in this setting, particularly for surgeons who practice routine intraoperative evaluation of the CBD. Although the learning curve for effective performance of laparoscopic ultrasonography examination is not long, surgeons should receive expert mentoring and formal instruction in ultrasonography before attempting it. During the first few attempts, it may be instructive to perform intraoperative laparoscopic ultrasonography in conjunction with fluorocholangiography. It should be emphasized that intraoperative laparoscopic ultrasonography is not a replacement for intraoperative cholangiography if the purpose of the examination is to define an anomalous anatomy or to evaluate a suspected injury or leak.

**Step 6: Dissection of Gallbladder from Liver Bed**

The gallbladder is grasped near the cystic duct insertion and pulled down toward the right anterosuperior iliac spine, placing the areolar tissue between the gallbladder and liver anteriorly.
under tension. The areolar tissue is cauterized with an L-shaped hook dissector or spatula, and dissection is carried upward as far as possible for as long as there is sufficient exposure. When exposure begins to diminish, the cystic duct end of the gallbladder should be pulled up toward or over the left lobe of the liver to expose the posterior inferior attachments of the gallbladder. A two-handed approach by the surgeon facilitates this dissection. It is sometimes helpful to apply downward and lateral traction on the forceps grasping the fundus. Bleeding during this stage generally indicates that the surgeon has entered the wrong plane and dissection has entered the liver. Bleeding can usually be readily controlled with the electrocautery. In some difficult cases (e.g., an intrahepatic gallbladder), it may be prudent to leave some of the tissue intrahepatic gallbladder), it may be prudent to leave some of the tissue residual CO2 should be removed from the abdominal cavity. An amount of blood, a major vascular injury may have occurred, and immediate laparotomy is indicated. Because the problem at this point is a needle injury, it can usually be repaired easily and without serious sequelae.

**Need for drainage** The decision to place a drain after laparoscopic cholecystectomy should be governed by the same principles applied to patients undergoing open cholecystectomy. There are two main indications for drainage: (1) the cystic duct was not closed securely, and (2) the CBD was explored by either a direct or a transcystic approach.

Drain placement is easily accomplished. A closed suction drain is inserted intra-abdominally through the 10 mm operating port. A grasping forceps placed through the right lateral port is used to pull one end of the drain out through the abdominal wall. The other end is then positioned according to the surgeon’s preference, usually in the subhepatic space.

**Complications**

**Intraoperative**

**Veress needle injury** A syringe must always be attached to the Veress needle, and fluid must be aspirated before insufflation is initiated: failure to do so may lead to insufflation into a vessel and consequently to massive gas embolism. If the aspirate from the syringe attached to the Veress needle contains copious amounts of blood, a major vascular injury may have occurred, and immediate laparotomy is indicated. Because the problem at this point is a needle injury, it can usually be repaired easily and without serious sequelae.

Puncture of the bowel by a Veress needle is usually signaled by aspiration of bowel contents through the needle. If this occurs, the needle should be withdrawn and the approximate course and
direction of the puncture remembered. The initial trocar should then be inserted by means of the open technique, under direct vision, to ensure that the undersurface of the abdominal wall is free of adherent bowel. Once pneumoperitoneum is created, careful examination of the abdomen through the laparoscope is undertaken. In most cases, either further leakage of bowel contents, staining of the serosal surface with bowel contents, or an echymosis on the serosal surface of the bowel helps the surgeon locate the site of the bowel injury. If echymosis is present without spillage of bowel contents, the bowel loop should be marked with a suture and inspected at the end of the procedure. If ongoing leakage of bowel contents is noted, the injured loop of bowel can be either repaired by means of laparoscopic suturing or grasped with anatraumatic forceps and gently withdrawn through an enlarged umbilical incision for suture repair. The bowel is returned to the peritoneal cavity and the laparoscopic cholecystectomy completed.

Improper placement of the Veress needle into the omentum, the retroperitoneum, or the preperitoneal space may be signaled by high inflation pressures, uneven distribution of the gas on percussion, or marked subcutaneous emphysema. If such misplacement goes unrecognized, creation of a safe intraperitoneal space is impossible, and subsequent blind insertion of the trocar may result in injury to an intraperitoneal structure.

**Trocar injury**

Trocar injury to blood vessels or bowel is much more dangerous than Veress needle injury to the same structures. Major vascular injuries virtually never occur when trocars are placed under direct vision; however, they remain a potentially lethal—though rare—complication of percutaneous trocar insertion. If active bleeding follows removal of the trocar from the cannula, prompt laparotomy is mandatory; if bleeding passes unnoticed and insufflation begins, massive air embolism will result. At the time of laparotomy, both the anterior and the posterior wall of the vessel must be examined after proximal and distal control of the vessel have been obtained.

Bowel injuries can result from either percutaneous or open insertion of the initial trocar. With open insertion, the bowel injury should be immediately obvious and can be repaired after the injured bowel is pulled through an enlarged umbilical incision; laparoscopic cholecystectomy can then proceed. Bowel injuries caused by percutaneous insertion may occur even in the absence of abdominal wall adhesions and can be managed in the same way as those caused by open insertion. The one caveat is that it is possible to spear the bowel in a through-and-through fashion so that when the laparoscope is inserted through the trocar, the view is normal and the injury is not recognized. This type of injury can be diagnosed only if the laparoscope is repositioned to the operating port at some time during the procedure and the undersurface of the umbilical site is carefully examined. This step is mandatory during the course of the operation, preferably early.

**Bleeding**

Abdominal wall. Bleeding from the abdominal wall can usually be prevented by careful trocar placement. The abdominal wall should be transilluminated before percutaneous trocar insertion and the larger vessels avoided. If a vessel is speared, the cannula usually tamponades the bleeding reasonably effectively during the procedure.

Once the procedure is completed, each trocar is removed under direct vision. If bleeding follows the removal of a trocar, the puncture hole can be occluded with digital pressure to maintain pneumoperitoneum and the bleeding controlled by cautery or suture repair. Alternatively, the surgeon may place a Foley catheter through the trocar site with a stylet, inflate the balloon, and place traction on the catheter for 4 to 6 hours; however, tissue ischemia can make this technique quite painful.

**Omental or mesenteric adhesions.** Generally, omental adhesions can be bluntly teased from their attachments to the gallbladder, with the plane of dissection kept close to the gallbladder, where the adhesions are less vascular. Adhesions to the liver should be taken down with the electrocautery to prevent capsular tears. Persistent bleeding from omental adhesions is unusual but can be managed by means of electrocauterization (with care taken to avoid damage to the duodenum or colon) or the application of hemostatic clips or a pretied ligating loop.

**Cystic artery branch.** Arterial bleeding encountered during dissection in Calot’s triangle is usually from loss of control of the cystic artery or one of its branches. Biliary surgeons must be aware of the many anatomic variations in the vasculature of the gallbladder and the liver. Because the main cystic artery frequently branches, it is common to find more than one artery if dissection is maintained close to the gallbladder. If what seems to be the main cystic artery is small, a posterior cystic artery may be present and may have to be clipped during the dissection.

Prevention of arterial bleeding begins by dissecting the artery carefully and completely before clipping and by inspecting the clips to ensure that they are placed completely across the artery without incorporating additional tissue (e.g., a posterior cystic artery or right hepatic artery). When arterial bleeding is encountered, it is essential to maintain adequate exposure and to avoid blind application of hemostatic clips or cautery. The laparoscope should be withdrawn slightly so that the lens is not spattered with blood. The surgeon should then pass anatraumatic grasping forceps through a port other than the operating port and attempt to grasp the bleeding vessel. An additional trocar may have to be inserted for simultaneous suction-irrigation. Once proximal control is obtained, the operative field should be suctioned and irrigated to improve exposure. Hemostatic clips are then applied under direct vision; in addition, a sponge may be introduced to apply pressure to the bleeding vessel. Conversion to open cholecystectomy is indicated whenever bleeding cannot be promptly controlled laparoscopically.

**Liver bed.** Bleeding from the liver bed may be encountered when the wrong plane is developed during dissection of the gallbladder. Patients who have portal hypertension, cirrhosis, or coagulation disorders are at particularly high risk. Control of bleeding requires good exposure, accomplished via lateral and superior retraction of the gallbladder; hence, all bleeding should be controlled before the gallbladder is detached from the liver bed. Most liver bed bleeding can be controlled with the electrocautery, and it should be controlled as it is encountered to allow exposure of the specific bleeding site. Either a hook-shaped or a spatula-shaped coagulation electrode is effective. If oozing continues, oxidized cellulose can be placed as a pack through the operative port and pressure applied on the raw surface of the liver. If needed, fibrin glue can be applied to the bleeding raw surface.

**Postoperative**

If a patient (1) complains of a great deal of abdominal pain necessitating systemic narcotics, (2) has a high or prolonged fever, (3) experiences ileus, or (4) becomes jaundiced, an intra-abdominal complication may have occurred. Blood should be drawn for assessment of the white blood cell count, hemoglobin concentration, liver function, and serum amylase level. Abdominal ultra-
Aspirate fluid.

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5 Gastrointestinal Tract and Abdomen

21 Cholecystectomy and Common Bile Duct Exploration — 15

**Figure 19 Laparoscopic cholecystectomy.** Shown is an algorithm outlining a screening approach that is often useful when the patient shows signs (e.g., pain, fever, or ileus) that are suggestive of a postoperative intra-abdominal complication, such as fluid collection or bile leakage.

**Fluid collection or bile leakage** When a significant fluid collection is seen, it should be aspirated percutaneously under ultrasonographic guidance. If the fluid is blood and the patient is hemodynamically stable and requires no transfusion, observation of the patient and culture of the fluid are usually sufficient. If the fluid is enteric contents, immediate laparotomy is indicated. If the fluid is bile and the patient is ill, immediate laparotomy should be considered; if the patient is stable and the appropriate facilities are available, MRCP or ERCP may be performed to identify the site of bile leakage, determine whether obstruction is also present, and assess the integrity of the extrahepatic biliary tree. If the bile ducts are in continuity, the bile is coming from the cystic duct stump or a small lateral tear in the bile duct, ES, with or without stenting, usually controls the leak. Percutaneous placement of a drain under ultrasonographic guidance allows control of the bile leakage and measurement of the quantity of fluid present.

**Fever** Postoperative fever is a common complication of laparoscopic cholecystectomy. As noted, it may be indicative of a complication such as a bile collection or bile leakage. Other common reasons for postoperative fever (e.g., atelectasis) should also be considered.

**Abnormal liver function** When postoperative blood tests indicate significantly abnormal liver function, possible causes include injury to the biliary tree and retained CBD stones [see Figure 20].33 Cholangiography is required, even if it was performed intraoperatively. If MRCP or ERCP yields normal results, observation is sufficient; the abnormalities may be attributable to a passed stone or drug-related cholestasis. If stones are present, ES can usually solve the problem. If ERCP demonstrates extravasation of bile, it is important to establish whether the CBD is in continuity. If the duct is interrupted, early reoperation, ideally at a specialized center, is the best option. If the duct is in continuity, endoscopic and radiologic techniques may successfully resolve the problem without substantial morbidity.34,35 Percutaneous drainage is instituted to control the fistula, and sphincterotomy or stenting is useful to overcome any resistance at the sphincter of Oddi. Any retained stones causing distal obstruction should also be removed. Major ductal injuries usually call for operative repair. When such an injury is identified at operation, the surgeon must decide whether to attempt repair immediately; this decision should be based on the surgeon’s experience with reconstructive biliary surgery and on the local expertise available. At a minimum, adequate drainage must be established. Most major ductal injuries are not in fact identified intraoperatively. When such an injury is identified postoperatively, adequate drainage must be established and the anatomy of the injury clarified as well as possible before repair. MRCP or transhepatic cholangiography may be required to delineate the anatomy of the proximal biliary tree when ERCP does not opacify the biliary tract above the injury. If surgical repair is indicated, it should be performed by a surgeon experienced in complex biliary tract procedures. Often, referral to a specialized center is the most appropriate decision, especially in the case of more proximal biliary injuries.

**SPECIAL CONSIDERATIONS**

**Conversion to Laparotomy**

Conversion from laparoscopy to laparotomy may be required in any laparoscopic cholecystectomy, in accordance with the judgment of the surgeon. The most common reason for such conversion is the inability to identify important anatomic structures in the region of the gallbladder. Distorted anatomy may be the result of previous operations, inflammation, or anatomic variations. Conversion may also be required because of an intraoperative complication [see Complications, Postoperative, above]. Ideally, the surgeon would wish to convert before any complication occurs. It must be emphasized that conversion to open surgery should not be considered a failure or a complication. Rather, it should be considered a prudent maneuver for achieving the desired objective—namely, safe removal of the gallbladder. Accordingly, every patient consent obtained for a laparoscopic cholecystectomy must explic-
postoperative information. It is clearly useful to allow for the possibility of conversion to an open procedure. Attempts have been made to predict the probability of conversion on the basis of preoperative information. 

Factors found to be predictive of an increased probability of conversion include acute cholecystitis, obesity, previous upper abdominal operations (especially gastroduodenal), multiple gallbladder attacks over a long period, and severe pancreatitis. Factors not associated with an increased likelihood of conversion are jaundice, previous ES, previous lower abdominal procedures, stomas, mild pancreatitis, and diabetes.

On the basis of our data, a 45-year-old woman with no history of acute cholecystitis and no gallbladder wall thickening has a probability of conversion lower than 1%; such a patient is a good candidate for laparoscopic cholecystectomy in an outpatient setting. Conversely, a 70-year-old man with acute cholecystitis and ultrasonographic evidence of gallbladder wall thickening has a probability of conversion of about 30%; such a patient would be better managed in a traditional hospital environment.

Acute Cholecystitis

Laparoscopic cholecystectomy has been shown to be safe and effective for treating acute cholecystitis. There are, however, several technical problems in this setting that must be addressed if the procedure is to be performed with minimal risk. It should also be recognized that the probability of conversion to laparotomy is greatly increased in these circumstances. There appears to be no advantage to delaying surgery in patients with acute cholecystitis, even if rapid improvement is noted with nonoperative management. Many patients return within a short time with recurrent attacks, and delaying surgery does not reduce the probability of conversion.

Technical difficulties associated with cholecystectomy for acute cholecystitis include dense adhesions, the increased vascularity of tissues, difficulty in grasping the gallbladder, an impacted stone in the gallbladder neck or the cystic duct, shortening and thickening of the cystic duct, and close approximation of the CBD to the gallbladder wall.

The surgeon should not hesitate to insert additional ports (e.g., for a suction-irrigation apparatus) if necessary. Because the tense, distended gallbladder is difficult to grasp reliably, it should be aspirated through the fundus early in the procedure, as previously described. If the graspers fail to grasp the wall or cause it to tear, exposure of Calot’s triangle can be achieved by propping up or leveling the neck of the gallbladder and the right liver with a blunt instrument. A sponge can be used for this purpose, thereby reducing the potential trauma of the retraction. This maneuver is also useful when an impacted stone in the neck of the gallbladder prevents the surgeon from grasping the gallbladder in the area of Hartmann’s pouch. Dense adhesions that may be present between the gallbladder and the omentum, duodenum, or colon should be dissected bluntly (e.g., with a suction tip). Because the tissues are friable and vascular, oozing may be encountered. Electrocauterization should be only sparingly employed until the vital structures in Calot’s triangle are identified. Instead, the surgeon should move to another area of dissection, allowing most of the oozing to coagulate on its own. Liberal use of suction and irrigation will keep the operative field free of blood.

In the identification of anatomic structures, it is important to keep dissection close to the gallbladder wall, working down from the gallbladder toward Calot’s triangle. Dissection of the lower part of the gallbladder from the liver bed early in the operation may aid in identification of the gallbladder neck–cystic duct junction (analogous to an open, retrograde dissection). The surgeon should be aware that edema and acute inflammation may cause foreshortening of the cystic duct. If the anatomy cannot be identified, preliminary cholangiography through the emptied gallbladder may indicate the position of the cystic duct and the CBD.

Often, the obstructing stone responsible for the acute attack is in the neck of the gallbladder; thus, the cystic duct will be normal and easily secured with clips. If the stone is in the cystic duct, it must be removed before the duct is clipped or ligated. A thickened, edematous cystic duct is better controlled by ligation with an extracorporeal tie or a ligating loop than by clipping. If closure of the cystic duct is interrupted or lacks continuity, the surgeon should not hesitate to insert additional ports (e.g., for a suction-irrigation apparatus) if necessary. Because the tense, distended gallbladder is difficult to grasp reliably, it should be aspirated through the fundus early in the procedure, as previously described. If the graspers fail to grasp the wall or cause it to tear, exposure of Calot’s triangle can be achieved by propping up or leveling the neck of the gallbladder and the right liver with a blunt instrument. A sponge can be used for this purpose, thereby reducing the potential trauma of the retraction. This maneuver is also useful when an impacted stone in the neck of the gallbladder prevents the surgeon from grasping the gallbladder in the area of Hartmann’s pouch. Dense adhesions that may be present between the gallbladder and the omentum, duodenum, or colon should be dissected bluntly (e.g., with a suction tip). Because the tissues are friable and vascular, oozing may be encountered. Electrocauterization should be only sparingly employed until the vital structures in Calot’s triangle are identified. Instead, the surgeon should move to another area of dissection, allowing most of the oozing to coagulate on its own. Liberal use of suction and irrigation will keep the operative field free of blood.

Identification of patients at risk

About 10% of all patients undergoing cholecystectomy for gallstones will also have choledocholithiasis. To select from the various diagnostic and therapeutic options for managing choledocholithiasis, it is helpful to know preoperatively whether the patient is at high, moderate, or low risk for stones. Patients with obvious clinical jaundice or cholangitis, a dilated CBD, or stones visualized in the CBD on preoperative ultrasonography are likely to have choledocholithiasis (risk > 50%). Patients who have a history of jaundice or pancreatitis, elevated preoperative levels of alkaline phosphatase or bilirubin, or ultrasonographic evidence of multiple small gallstones are somewhat less likely to have choledocholithiasis (risk, 10% to 50%). Patients with large gallstones, no history of jaundice or pancreati-
Diastasis; larger stones (4 to 8 mm) are retrieved under directed baskets and generally do not necessitate cystic duct exploration.

Smaller than 4 mm can usually be retrieved in fluoroscopically guided baskets. If a stone of this size does not pass intraoperatively, it will usually pass on its own postoperatively. If a stone of this size does not pass intraoperatively, it will usually pass on its own postoperatively. If a stone of this size does not pass intraoperatively, it will usually pass on its own postoperatively.

Diagnostic and therapeutic options One argument for routine intraoperative cholangiography is that it is a good way of identifying unsuspected CBD stones. However, more selective approaches to diagnosing choledocholithiasis make use of preoperative cholangiography via MRCP, EUS, or, more invasively, ERCP [see 5:18 Gastrointestinal Endoscopy]. Preoperative identification of choledocholithiasis allows the surgeon to attempt preoperative clearance of the CBD by means of ES or intraoperative clearance during laparoscopy, depending on his or her expertise. Preoperative cholangiography is suggested when the patient’s history and the results of laboratory and diagnostic tests suggest that there is a moderate or high risk of CBD stones. It is our practice to have patients at high risk for CBD stones undergo ERCP and ES if warranted. For patients at moderate risk, MRCP or EUS is done first, followed by therapeutic ERCP if CBD stones are identified. Intraoperative cholangiography can also be used to identify choledocholithiasis. ERCP with ES may result in pancreatitis, perforation, or bleeding and carries a mortality of approximately 0.2%.

When stones are detected during the operation, the options include laparoscopic transcystic duct exploration, laparoscopic choledochotomy and CBD exploration, open CBD exploration, and postoperative ERCP/ES.10,42 If a single small (~2 mm) stone is visualized, it can probably be flushed into the duodenum by flushing the CBD via the cholangiogram catheter and administering glucagon, 1 to 2 mg I.V., to relax the sphincter of Oddi. Even if a stone of this size does not pass intraoperatively, it will usually pass on its own postoperatively.

Laparoscopic transcystic CBD exploration Access to biliary tree. The cholangiogram is reviewed; the size of the cystic duct, the site where the cystic duct inserts into the CBD, and the size and location of the CBD stones all contribute to the success or failure of transcystic CBD exploration.31-33 For example, transcystic exploration is extremely challenging in a patient who has a long, spiraling cystic duct with a medial insertion. The size of the stones to be removed dictates the approach to the CBD: stones smaller than 4 mm can usually be retrieved in fluoroscopically directed baskets and generally do not necessitate cystic duct dilatation; larger stones (4 to 8 mm) are retrieved under direct vision with the choledochoscope.

A hydrophilic guide wire is inserted through the cholangiogram catheter into the CBD under fluoroscopic guidance. The cholangiogram catheter is then removed. If the largest stone is larger than the cystic duct, dilatation of the duct is necessary, not only for passage of the stone but also to allow passage of the choledochoscope, which may be 3 to 5 mm in diameter.

Dilatation is accomplished with either a balloon dilator or sequential plastic dilators. Because plastic dilators may cause the cystic duct to split, balloon dilatation is recommended. A balloon 3 to 5 cm in length is passed over the guide wire and positioned with its distal end just inside the CBD and its proximal end just outside the incision in the cystic duct. The balloon is then inflated to the pressure recommended by the manufacturer and observed closely for evidence of shearing of the cystic duct. The cystic duct should not be dilated to a diameter greater than 8 mm. Larger stones in the CBD may be either fragmented with electrohydraulic or mechanical lithotripsy, if available, or removed via choledochotomy.

Once dilatation is complete, the guide wire may be removed or left in place to guide passage of a choledochoscope or baskets. When the choledochoscope is used, a second incision in the cystic duct, close to the CBD, avoids Heister’s valves and allows removal of the guide wire. If baskets are used, a 6 French plastic introducer sheath may be inserted through the trocar used for cholangiography into the cystic duct. This sheath is especially useful if multiple stones must be removed.

Fluoroscopic wire basket transcystic CBD exploration. Stones smaller than 2 to 4 mm that do not pass with irrigation through the cholangiocatheter after injection of glucagon can usually be retrieved by using a 4 French or 5 French helical stone basket passed into the CBD over a guide wire under fluoroscopic guidance. The baskets can be passed alongside the cholangiocatheter or inserted via a plastic sheath replacing the cholangiocatheter. The basket is opened in the ampulla of Vater, pulled back into the CBD, and rotated clockwise until the stone is entrapped. The stone and basket are then removed together. A Fogarty catheter should not be used, because the stones are likely to be pulled up into the hepatic ducts, where they are much more difficult to remove.

Endoscopic transcystic CBD exploration. When stones are 4 to 8...
mm in diameter, the helical stone basket wires are generally too close together to permit retrieval. Hence, choledochoscopic basketing is utilized. A 7 to 10 French choledochoscope with a working channel is either passed over the guide wire or inserted directly into the cystic duct. Because the usual grasping forceps may damage the choledochoscope, forceps with rubber-covered jaws should be used. A separate camera should be inserted onto the choledochoscope, and the image it produces can be displayed on the monitor by means of an audiovisual mixer (i.e., a picture within a picture) or displayed on a separate monitor.

Once the choledochoscope enters the cystic duct, warm saline irrigation is begun under low pressure to distend the CBD and provide a working space. The choledochoscope usually enters the CBD rather than the common hepatic duct. When a stone is seen, a 2.4 French straight four-wire basket is inserted through the operating port. The stones closest to the cystic duct are removed first, by advancing the closed basket beyond each stone, opening the basket, and pulling the basket back, thereby trapping the stone. The basket is then closed and pulled up against the choledochoscope so that they can be withdrawn as a unit. Multiple passes may be required until the duct is clear. A completion cholangiogram is done to ensure that the duct is clear and to rule out proximal stones. The dilated, traumatized cystic duct is ligated with a ligating loop rather than a hemostatic clip. If drainage is required, a red rubber catheter can be inserted into the CBD via the cystic duct.

Laparoscopic CBD exploration Large stones (> 1 cm), as well as most stones in the common hepatic ducts, are not retrievable with the techniques described above. Ductal clearance can be achieved via choledochotomy if the duct is dilated and the surgeon is sufficiently experienced.46,47 The anterior wall of the CBD is bluntly dissected for a distance of 1 to 2 cm. When small vessels are encountered, it is preferable to apply pressure and wait for hemostasis rather than use the electrocautery in this area. Two stay sutures are placed in the CBD. An additional 5 mm trocar is placed in the right lower quadrant for insertion of an additional needle driver. A small longitudinal choledochotomy (a few millimeters longer than the circumference of the largest stone) is made with curved microscissors on the anterior aspect of the duct while the stay sutures are elevated. A choledochoscope is then inserted and warm saline irrigation initiated. In most cases, baskets should suffice for stone retrieval; however, lithotripter probes and lasers are available for use through the working channel of the choledochoscope. The choice of approach depends on availability and individual surgical experience.

Subsequently, a 12 or 14 French latex T tube is fashioned with
short limbs, placed entirely intraperitoneally to prevent CO₂ from escaping, and positioned in the CBD. The choledochotomy is then closed with fine interrupted absorbable sutures. The first suture is placed right next to the T tube, securing it distally, and the second is placed at the most proximal end of the choledochotomy; lifting these two sutures facilitates placement of additional sutures. Intracorporeal knots are preferred to avoid sawing of the delicate tissues. The end of the T tube is then pulled out through a trocar, and cholangiography is performed after completion of the procedure.

Open Cholecystectomy

Open cholecystectomy is usually reserved for patients in whom the laparoscopic approach is not feasible or is contraindicated. As such, it is typically performed only in the most difficult situations or when additional maneuvers such as CBD exploration are anticipated. Conversion from the laparoscopic to the open approach is not considered a complication and does not represent failure. Rather, conversion to this time-honored and effective procedure represents the prudent judgment of a safe surgeon.

OPERATIVE TECHNIQUE

The choice of incision depends on the surgeon’s experience and preference, along with patient factors such as previous surgical procedures and body habitus. Typically, open cholecystectomy is performed through a right subcostal (Kocher) incision, but it can also be approached through an upper midline incision or, less commonly, through a right paramedian or transverse incision. A mechanical retraction system should be used, if available, so that the hands of the participating surgeons are free; there is no good rationale for struggling to perform difficult biliary surgery with handheld retractors.

The abdomen is opened and then explored; the abdominal viscera are inspected and palpated and a retraction system is put in place. Long curved or angled clamps, such as Kelly or Mixter, are placed on the gallbladder fundus and infundibulum for the application of gentle traction. The fundus is elevated and the infundibulum is pulled laterally and away from the liver [see Figure 21]. If the gallbladder is not too inflamed and edematous, the procedure may be performed similarly to the typical laparoscopic approach: the surgeon identifies and ligates the cystic duct and artery, and then removes the gallbladder from the liver bed. With more difficult open cases, the above technique may not be possible. In such cases, a retrograde or so-called fundus down approach is usually employed. Staying as close to the gallbladder wall as is possible, the surgeon uses electrocautery or sharp and digital blunt dissection to remove the gallbladder from the liver bed, continuing downward to the cystic duct and artery [see Figure 22]. Anatomic variations of the duct and artery must always be anticipated. These structures can be very difficult to identify and safely dissect in cases of severe inflammation and markedly edematous tissues. In such cases, palpation and gentle digital blunt dissection of the duct and artery between thumb and index finger is useful [see Figure 23]. Opening the gallbladder to remove stones or aspirate bile or pus may be necessary when it is tense and distended or necrotic and gangrenous. As with laparoscopic cholecystectomy, it is critical to identify the cystic duct and artery and their anatomic relations to the gallbladder and common bile duct before division and to avoid injury to the common bile duct or common hepatic duct. The cystic duct and artery may be suture
ligated or divided between clips. Stones found in the cystic duct should be gently milked back into the gallbladder.

**SPECIAL CONSIDERATIONS**

**Cholangiography**

The indications for cholangiography are the same as for laparoscopic cholecystectomy. Several techniques for the performance of cholangiography can be utilized. Usually the same technique as for laparoscopic cholecystectomy is employed; the cystic duct is ligated or clipped high near the infundibulum and incised just below this point for insertion of a cholangiography catheter, which is secured against leakage by another clip or ligature. Alternatively, the cystic duct can be divided near the infundibulum and the gallbladder removed; then the cystic duct is cannulated. Needle puncture cholangiography can also be performed via the cystic duct or the common duct. Once cholangiography is complete, the gallbladder is removed and sent for pathologic examination. The operative field is inspected for hemostasis and irrigated. Any bile leak is identified. Drains are not routinely placed but can be used at the surgeon's discretion. If drains are used, a closed suction Jackson-Pratt or similar drain is recommended; the drain should be brought out through a separate stab incision.

**Open CBD Exploration**

Open common bile duct exploration has become a rare procedure, but it remains a skill that surgeons require. If ERCP has failed or is not possible, if the surgeon does not have the experience and necessary tools to perform laparoscopic duct exploration, or if laparoscopic efforts have failed, then open exploration becomes necessary. Ductal stones are identified either preoperatively or intraoperatively by ultrasound, cholangiography, or palpation.

Appropriate retraction and exposure are crucial. The anterior aspect of the duct is exposed over a distance of 1 to 2 cm, avoiding electrocautery during dissection. Two stay sutures of a 3-0 monofilament are placed lateral to the midline of the duct. The common hepatic duct is sharply opened with a No. 11 or No. 15 scalpel and longitudinally incised further with a Potts' arteriotomy or similar scissors. When performing these maneuvers, the surgeon must respect the arterial blood supply of the duct, which courses laterally on either side of the duct in the 3 o'clock and 9 o'clock positions. In some cases, stones are immediately visible and can simply be plucked from the duct once it is opened. Flushing the duct with saline, proximally and then distally, through a 12 or 14 French Foley or red rubber catheter may also clear the duct of stones. The intravenous administration of 1 to 2 mg of glucagon will relax the sphincter of Oddi, which may help in the flushing of stones from the duct. In some cases, stones will be impacted within the duct and will require additional maneuvers. Kocher’s maneuver (liberally mobilizing the lateral duodenum and head of the pancreas) will allow the surgeon to hold and palpate the duodenum, the head of the pancreas, and stones within the duct, facilitating instrumentation. Stone retrieval forceps, biliary Fogarty catheters, and wire baskets can all be employed to retrieve stones. A choledochoscope can also be used, either at the outset of exploration or for stone retrieval, if simpler maneuvers are not successful.

Either T tube cholangiography or choledochoscopy may be employed to confirm clearance of ductal stones. If no stones are...
present, primary closure of the choledochotomy has been successfully employed, although most surgeons will leave in place a 12 or 14 French tube, which is brought out through a separate stab incision in the right lateral abdominal wall [see Figure 25]. If stone clearance is not achieved, a T tube is mandatory for decompression of the biliary tract and to provide a route for future duct instrumentation. The T tube is connected to a bag for free drainage. Several days later, cholangiography is repeated.

If it shows good flow into the duodenum without obstruction, the tube may be clamped and removed at the 2-week mark. If there are retained stones, a more mature tract must be allowed to develop over 4 to 6 weeks for future instrumentation and stone retrieval. Retained stones may require ERCP, percutaneous transhepatic instrumentation, T tube tract instrumentation, or combinations of these for removal.


References

20. SAGES Committee on Standards of Practice: SAGES Guidelines for Laparoscopic Surgery during Pregnancy. SAGES Publication #0023, Society of American Gastrointestinal Endoscopic Surgeons (SAGES), Santa Monica, California, 2000
Recommended Reading

74:755, 1994

Acknowledgments

Figures 2, 5 Tom Moore.
Figure 18 Courtesy of Nathaniel J. Soper, M.D., Northwestern University Feinberg School of Medicine, Chicago.
Figures 21 through 25 Alice Y. Chen.