Chapter 11
Laparoscopic Cholecystectomy

Laura N. Purcell and Anthony Charles

11.1 Introduction

The first laparoscopic cholecystectomy was performed in Germany in 1985 by Dr. Erick Muhe [1]. Over the last three decades, it has become the standard of care operation for the majority of gallbladder pathology, including biliary colic, acute and chronic cholecystitis, symptomatic cholelithiasis, choledocholithiasis, and biliary dyskinesia.

11.2 Clinical Presentation

Gall bladder disease, including acute cholecystitis, typically presents with symptoms which include nausea, emesis, fever, right upper quadrant pain (RUQ) tenderness, and Murphy's sign. Murphy's sign is the physical exam maneuver performed when the examiner elicits the arrest of inspiration when applying pressure to the patient's RUQ overlying the gallbladder, which results in pain from the inflamed gallbladder as it incites the peritoneal somatic pain fibers. The celiac axis innervates the gallbladder. Therefore, the pain often presents as epigastric pain, which transitions to RUQ pain as the parietal peritoneum is irritated from gallbladder inflammation. The fever is induced by cytokine release due to inflammation of the gallbladder. Occasionally, patients with gallbladder disease may present with jaundice, either

L. N. Purcell
Department of Surgery, University of North Carolina, Chapel Hill, NC, USA

A. Charles (✉)
Division of General and Acute Care Surgery, University of North Carolina School of Medicine, Chapel Hill, NC, USA
e-mail: anthchar@med.unc.edu

M. G. Patti et al. (eds.), *Techniques in Minimally Invasive Surgery*,
https://doi.org/10.1007/978-3-030-67940-8_11

due to necrotic or gangrenous gallbladder, or the presence of stone in the neck of the gallbladder that concomitantly compresses the common hepatic duct or choledocholithiasis.

11.3 Preoperative Workup

11.3.1 Laboratory Tests

Preoperative laboratory tests before performing a laparoscopic cholecystectomy should include a complete blood count, as an elevated white blood cell count is associated with acute cholecystitis. A liver function test is also imperative. Laboratory derangements due to biliary pathology will be evident in the levels of bilirubin, alkaline phosphatase, and serum transaminase. If there is concern about the level of biliary obstruction or biliary pathology, fractionation of the bilirubin may assist. Increases in conjugated bilirubin are due to reduced intracellular transport, excretion of conjugated bilirubin, or obstruction of the biliary tree. Alkaline phosphatase is seen in pathology with cholestasis, and elevated serum transaminase is non-specific and seen with hepatocellular injury [2]. If concerned for gallstone pancreatitis, amylase and lipase may be added. Lipase has a higher sensitivity and specificity than amylase for acute pancreatitis [3, 4].

11.3.2 Imaging

The gold standard initial imaging for biliary disease is a right upper quadrant ultrasound. Ultrasound findings indicative of acute cholecystitis include impacted stone in the neck of the gallbladder, positive sonographic Murphy's sign, thickened gallbladder wall (>3 mm), pericholecystic fluid, or distended or hydropic gallbladder.

The role computed tomography (CT) in the evaluation of biliary disease is expanding. It is especially useful when the presenting symptoms are unclear or when suspected gallbladder disease complications are present, such as gallbladder perforation or emphysematous cholecystitis. CT findings consistent with acute cholecystitis include gallstones, gallbladder distension, thickening of the gallbladder wall, as well as pericholecystic inflammation and fluid.

A hepatic iminodiacetic acid (HIDA) scan, otherwise known as biliary scintigraphy, cannot be used for anatomical delineation but can be used to examine the flow of bile from the liver. After injection of the iminodiacetic acid, it is processed in the liver and secreted in the bile. Failure of the gallbladder to fill on the HIDA scan within two hours indicates there is obstruction of the cystic duct, and therefore can assist with diagnosing acute cholecystitis. Also, it can identify obstructions in the biliary tree and bile leaks. It is the gold standard for diagnosing biliary dyskinesia, as it determines the physiologic ejection of the gallbladder when used with an injection of cholecystokinin.

The current, primary role of Endoscopic retrograde cholangiopancreatography (ERCP) is to treat patients in whom a gallstone has blocked the bile duct, causing jaundice, pancreatitis, or cholangitis. An ERCP is indicated before taking the patient to the operating room if concerned for choledocholithiasis.

11.4 Operative Technique

Performing a laparoscopic cholecystectomy can be divided into 11 steps as follows.

11.4.1 Step 1: Patient Positioning

The patient should be positioned supine on the operating table with both arms tucked. An operating room seatbelt should be placed across the patient's proximal thigh, so they do not slide when placed in reverse Trendelenburg. The monitors should be placed at eye level, cephalad to both patient shoulders for ease of viewing for the surgeon and first assistant. Place an orogastric tube for stomach decompression. The skin is initially prepared with chlorhexidine from just below the nipple line to the inguinal ligaments and laterally to the anterior superior iliac spine. Drape the operative field with sterile drapes. The surgeon stands on the left side of the patient.

Troubleshooting: Make sure that the patient is firmly placed in the bed, and the strap is appropriately tight to prevent the patient from sliding during reverse Trendelenburg. When tucking the arms, confirm all bony prominences are well padded to avoid complications such as neuropraxia and decubitus ulcers.

11.4.2 Step 2: Insufflation and Port Placement

There are two methods for acceptable insufflation of the perioneal cavity, the first is theVeress needle needle technique with a blind trocar placement or via optical access trocar or second, the Hasson open technique. For the Veress approach, make a 1 cm skin incision in the location of the desired Veress needle placement. The Veress needle can be placed in the left upper quadrant lateral to the epigastric vessels, overlaying the stomach or at the umbilicus. For patients without prior abdominal surgeries, our preference is at the umbilicus because the shortest distance between the abdominal wall and the peritoneal cavity is at the umbilical stalk. The location of placement will be determined by previous surgical incisions. Once the incision has been made, elevate the abdominal wall with two pairs of penetrating towel clamps, and the Veress needle is inserted in the incision. After the two clicking sounds are heard, an appropriate intraperitoneal location is confirmed by the free flow of saline through the needle after aspiration to exclude succus or blood. Once abdominal pressures have reached 8–10 mmHg, and the abdomen is

tympanic, a 5 mm port can be placed at the umbilicus via blind trocar placement or an optical access trocar. The port is placed by twisting and applying pressure while aiming the trocar towards the pelvis [5].

To perform a Hasson open technique, make a vertical or transverse, 10–12 mm incision at the umbilicus. The incision can be made inferior or superior to the umbilicus. Exact placement should be determined by the patient's body habitus and previous surgical scars. Dissect the subcutaneous fat and tissues using finger retractors and blunt dissection. Once the external fascia is identified, use a Kocher clamp to grasp the reflection of the linea alba onto the umbilicus and elevate it cephalad. Make a 10 mm vertical incision with the scalpel through the fascia. Once the fascia is incised, utilize blunt dissection to identify the peritoneum. The peritoneum is elevated with hemostats and carefully incised to open the peritoneal space. Confirm access to the peritoneal space by visualizing bowel or omentum.

Place two U stitches, one on either side of the fascial incision, are placed with 0 polyglactin suture on a curved needle and set aside to secure the Hasson port. Place a finger within the peritoneal cavity, and perform a sweeping motion to ensure peritoneal entry and release any adhesions near the port site. The port is placed within the incision and secured it with the tails of the stay sutures [6].

Troubleshooting: The location of the initial peritoneal access depends on whether the patient has previously had an abdominal operation. If performing a Veress access, avoid the umbilicus if the patient has had a prior midline abdominal surgery and instead attempt access in the left upper quadrant. In patients with prior abdominal surgeries, we strongly recommend performing a Hassan approach.

After placement Veress needle, if saline does not flow freely or if high pressures are being recorded when the gas is turned on, the Veress needle should be removed. A careful attempt at repositioning can be made. If repositioning was unsuccessful, a transition to a Hassan access is warranted.

Finally, if the patient becomes hypotensive or bradycardic upon insufflation, open the insufflation port and remove the CO2 connection to allow the intraabdominal pressure to return to normal.

11.4.3 Step 3: Peritoneal Inspection

Once the scope port is placed and the peritoneal cavity is insufflated, use the 5 mm, 30-degree scope if a 5 mm port was placed at the umbilicus or a 10 mm, 30-degree scope in at the umbilicus if a Hasson open technique was performed. Focus and white-balance the laparoscope before advancing it slowly into the abdominal cavity. Inspect the bowel inferior to port placement to ensure no bowel injury during port placement. Subsequently, visualize all four quadrants of the abdomen to confirm the diagnosis and rule out other simultaneous intraabdominal pathology.

Troubleshooting: Occasionally, you may insufflate the preperitoneal space or the falciform ligament. This will reduce and is not of consequence. Make sure to examine the abdomen to look for succus to rule out a bowel injury, or any signs of bleeding that does not appear to be drop-down from the abdominal wall.

11.4.4 Step 4: Port Placement and Exposure

With your camera placed through the umbilical port, place three ports at the subxiphoid, right anterior axillary line, and the right midclavicular line in the subcostal region. The first port to be placed is in the subxiphoid (midline) region. A 1.2-cm incision is made three fingerbreadths below the xiphoid process and deepened into the subcutaneous fat. An 12-mm trocar is advanced into the abdominal cavity under direct vision in the direction of the gallbladder through the abdominal wall, with care taken to enter just to the right of the falciform ligament. The table is then adjusted to place the patient in a reverse Trendelenburg position with the right side up to allow the small bowel and colon to fall away from the operative field.

A 5-mm grasper is placed through the 12-mm subxiphoid port and applied to the fundus of the gallbladder. The gallbladder is then elevated cephalad over the dome of the liver to facilitate the surgeon's choice of the optimal positions for the lateral 5-mm ports. The third port (5 mm) should be inserted at the midclavicular line, one fingerbreadth below the costal margin. This port is used to access the neck of the now-retracted gallbladder. The fourth port (5 mm) should be placed four fingerbreadths below the second port at the anterior axillary line. The fourth port will be used to elevate the fundus of the gallbladder with a locking traumatic grasper, over the dome of the liver, toward the right shoulder to expose the infundibulum and porta hepatis (Fig. 11.1). With a Hunter grasper in port#2 (Fig. 11.2), grasp the gallbladder infundibulum and retract in the inferolateral direction. This maneuver straightens the cystic duct to expose Calot's Triangle (i.e., retracts it at 90° from the common bile duct [CBD]) and helps protect the CBD from inadvertent injury) (Fig. 11.3) [7].

Troubleshooting: This step is critical; otherwise, you will struggle for the remainder of the case. Remember, the gallbladder will be retracted cephalad; therefore, the midclavicular line port has to have a direct shot to Calot'sTriangle. The midclavicular and anterior axillary line ports cannot be directly vertical to each other, or the two instruments to perform the retraction will clash. If the gallbladder is distended

Fig. 11.1 Internal Port Placement

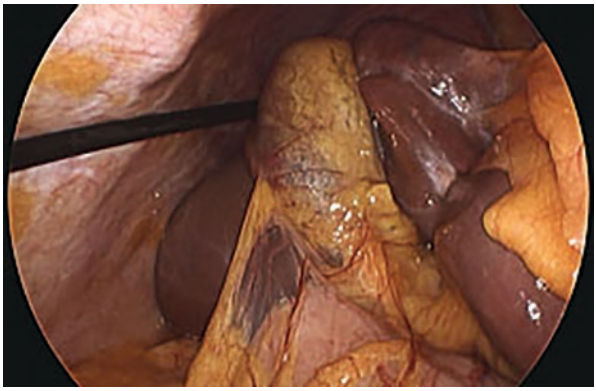

Fig. 11.2 Retracting the Fundus Over the Dome of the Liver Showing Adhesions and the Duodenum

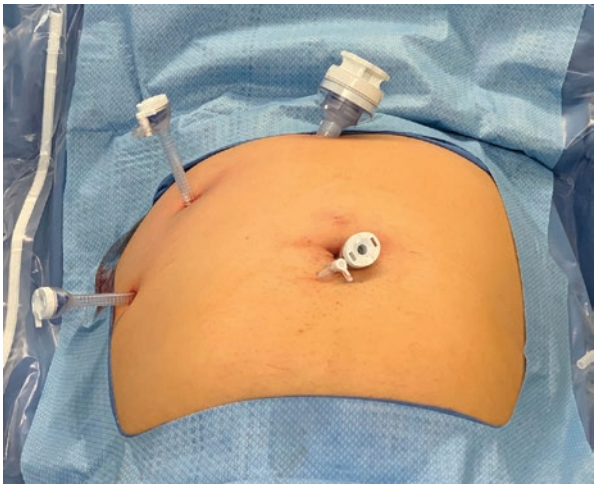

Fig. 11.3 External Port Placement

and it is challenging to manipulate the gallbladder with the graspers, perform a gallbladder decompression with an endoscopic needle attached to suction or a syringe.

11.4.5 Step 5: Adhesion Release

Once the ports are placed, use atraumatic graspers to remove the adhesions between the gallbladder and the omentum, duodenum, or colon. Then use graspers to grasp the adhesions close to the gallbladder and pull them towards the infundibulum to release the adhesions. Grasp as close to the gallbladder as possible to reduce bleeding or carefully lysed with a hook cautery. The authors prefer to use an L-hook electrocautery, which allows a very clean and delicate dissection. Continue until the gallbladder is free from all adhesions, and the colon and duodenum are removed from the operative field.

Troubleshooting: If the adhesions are challenging, you may need to utilize the hook cautery to help release the adhesions.

11.4.6 Step 6: Visualizing Calot's Triangle

Calot's Triangle is the anatomical space that contains the cystic artery. The cystic artery's landmark is the lymph node that overlies it, known as Calot's node. Its borders are the cystic duct laterally, the common hepatic duct medially, and the edge of the liver superiorly. To best expose this area, use an atraumatic grasper, such as a Hunter grasper to retract the infundibulum and pull inferolateral. Using a Maryland or a hook cautery, incise the peritoneum overlying the infundibulum, to avoid injuring the cystic artery or duct. Pull the peritoneum inferiorly, in line with the infundibulum, to expose the cystic artery and the cystic duct (Fig. 11.4).

Troubleshooting: Begin dissection near the gallbladder neck. Retract and dissect from the known to unknown to prevent injuring critical structures, such as the common bile duct or the duodenum.

11.4.7 Step 7: Critical View of Safety

To obtain the critical view, continue dissecting the peritoneum as was initiated in Step 6 until the cystic plate is taken down, and the inferior 1/3 of the gallbladder is separated from the liver. Once the peritoneum is taken down, clean carefully the tubular structures. This can be accomplished with careful dissection using the Maryland dissector and Kittners (Endo Peanut). Dissection is complete when the cystic duct and the cystic artery are the only two structures seen entering the gallbladder, and the liver is visible in the background. At this point, the critical view of safety has been achieved. This critical view must be obtained before any structures are clipped or transected (Fig. 11.5).

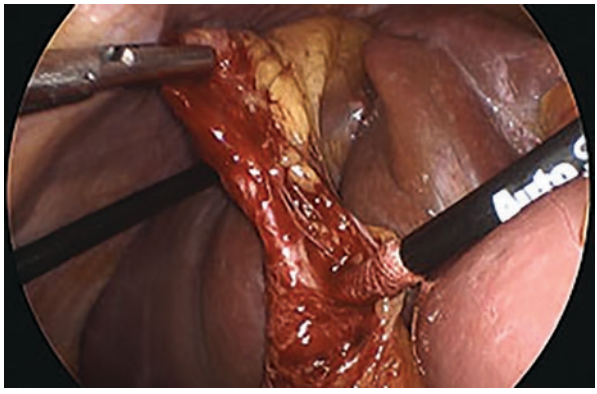

Fig. 11.4 Visualizing Calot's Triangle

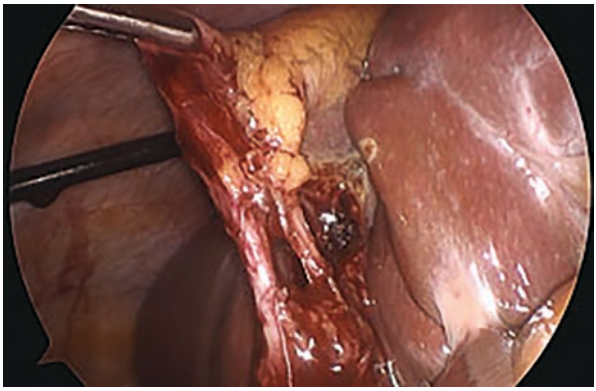

Fig. 11.5 Critical View of Safety

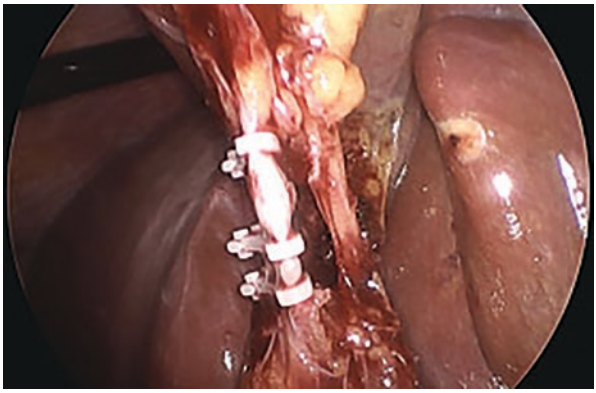

Fig. 11.6 Clipping the Ductal Structures

Troubleshooting: This step takes time and requires patience. Translucent tissues can be cut or cauterized without issue, those which cannot, need to be thinned until structures can be identified within.

11.4.8 Step 8: Clip and Transect Cystic Duct and Cystic Artery

After obtaining the critical view, place two clips on the cystic duct. If the anatomy is not clear and ductal structures are not clearly delineated or if the patient had choledocholithiasis and an ERCP was not performed, at this time, perform a cholangiogram and potentially a laparoscopic common bile duct exploration. Otherwise, place three clips on both the cystic artery duct and artery, two clips on the patient side, and one clip on the specimen side. Transect the tubular structures between the clips with the endoscopic scissors (Fig. 11.6).

Troubleshooting: Occasionally, the cystic artery bifurcates prior to entering the gallbladder, clip before the bifurcation, or clip each branch separately. When the

cystic duct is large, several options may be considered, including an endoscopic stapler, Endoloops, and the Hem-o-lock clip technique.

11.4.9 Step 9: Mobilization and Removal of Gallbladder off the Gallbladder Fossa

Using electrocautery, remove the gallbladder from the gallbladder fossa of the liver. This can best be performed by using an atraumatic grasper in the midclavicular line port and retract the gallbladder neck. Using the hook cautery in the subxiphoid port, cauterize from side to side at the lines of tension moving from the gallbladder neck towards to the gallbladder fundus peeling the gallbladder off the fossa. Use the atraumatic grasper to reposition the gallbladder as you progress and apply traction and gain new lines of tension. As in any surgical procedure, traction-countertraction is essential. To minimize wasted motion, peel the gallbladder as far as can go before changing positions of the atraumatic grasper.

Before the last strands connecting the gallbladder to the liver are divided, perform a final inspection of the gallbladder fossa and the clipped cystic structures. Any bleeding points in the gallbladder fossa should be controlled at this time before the gallbladder is completely separated from the liver (Fig. 11.7).

Troubleshooting: This portion of the operation is challenging. You may encounter bleeding from the gallbladder fossa as the gallbladder is removed. If you encounter bleeding, turn the electrocautery up to 60 watts and ensure hemostasis as you encounter bleeding. If the gallbladder is inadvertently perforated and there is bile and stone spillage, make every effort to thoroughly irrigate the right upper quadrant and extract the stones. Retained stones can cause future problems, such as chronic abscesses, fistulas, wound infections, and bowel obstructions. If unable to find the stones, look at Morison's pouch or the retrohepatic space by the abdominal wall.[22] Take care not to injure the diaphragm with the cephalad retraction of the gallbladder and the use of electrocautery near the diaphragm.

Fig. 11.7 Mobilization of Gallbladder off the Gallbladder Fossa

11.4.10 Step 10: Remove Gallbladder from the Peritoneal Space

Using a grasper in port #3 or #4, grasp the gallbladder and hold it over the right upper quadrant over the liver. Place the endoscopic retrieval bag through the 10/12 port, either at the umbilicus or the subxiphoid port. Place the gallbladder into the endoscopic retrieval pouch. Follow the manufacturer's instructions to close the bag. The authors prefer to leave the bag suspended from the subxiphoid trocar while they replace the camera through the same port and perform the final inspection and washout. Return the table to the neutral position. The gallbladder bed and the perihepatic spaces are irrigated and suctioned to ensure adequate hemostasis and removal of any debris or bile that may have spilled. The gallbladder is removed through the 10/12 mm port site after removing the trocar under direct visualization to ensure that stone spillage or bag perforation does not occur (Fig. 11.8).

Troubleshooting: If you have difficulties removing the gallbladder through the 10/12 mm port site, increase the port site with Kelly clamps or place Kelly on the top of the endoscopic retrieval pouch for an evenly distributed force on the bag. If the endoscopic retrieval pouch breaks, well irrigate the wound as the contamination predisposes the patient to wound infections.

11.4.11 Step 11: Close the Incisions

Remove the subcostal ports under direct visualization and desufflate the abdomen by removing the 10/12 mm port obturator. Remove the 10/12 mm port. Close the fascia at the 10/12 mm port site with the stay sutures placed during the Hassan port placement or use a #0 vicryl on a UR 6 needle to close the fascia. All of the skin incisions are closed with 4–0 absorbable monofilament suture, followed by cyanoacrylate tissue adhesive.

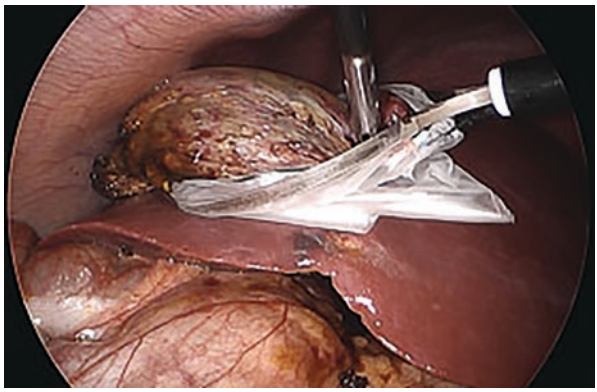

Fig. 11.8 Placing Gallbladder in Endoscopic Retrieval Bag

Troubleshooting: Make sure the fascia is identified as the 10/12 mm port site to ensure the fascia closed to prevent a hernia from occurring. If having challenges with a UR 6 needle, a Ranfac needle can be used to obtain adequate bites of the fascia.

11.5 Indications to Convert to an Open Cholecystectomy

The majority of gallbladder disease can be managed with laparoscopic cholecystectomy, and rarely an open operation will need to be performed. However, conversion from laparoscopic to open cholecystectomy needs to occur if the intraperitoneal adhesions are too dense, when the gallbladder and biliary anatomy is unclear, or when dissection progress is stalled to safely operate or if the gallbladder is to friable to grasp. Also, if a bile duct injury is identified or uncontrolled bleeding occurs during a laparoscopic procedure, conversion to an open procedure needs to occur to obtain visualization, control hemorrhage or to repair injured common bile or hepatic ducts.

11.5.1 Complications

Complications after laparoscopic cholecystectomy are rare but can include bleeding, retained gallstones, or common bile duct injury [8]. Complications that present themselves within the first two days include bleeding and bile duct injury. Most postoperative bleeding after laparoscopic cholecystectomies is self-limited. If a patient's hemoglobin continues to drop, interventional radiology is warranted. However, if the patient becomes hemodynamically unstable, they need to return to the operation room to find the source of the bleeding, usually from the cystic artery stump.

The most feared complication is a bile duct injury, which is primarily due to poor visualization due to inflammation, inappropriate exposure, and aggressive hemostasis during the operation. After identification of the bile duct injury, which usually occurs post-operatively, the first steps are to obtain infection control with percutaneous drainage of biloma and antibiotics. After identification of the injury location with ERCP or MRCP, consult interventional gastroenterology or a hepatobiliary surgeon to obtain biliary-enteric continuity.

Within the first week after cholecystectomy, a bile leak can result in a biloma. Patients may present with fever, chills, right upper quadrant pain, jaundice, bile leakage from the incision or in a drain, persistent anorexia, or bloating. Bile maybe from the Ducts of Luschka, accessory bile ducts that drain from the liver directly into the gallbladder, or from a cystic duct stump leak. The management includes an endoscopic retrograde cholangiopancreatography (ERCP) to identify the source of the leak. If it is due to a cystic duct stump leak, place a stent in the common bile duct

to the common hepatic duct, and a sphincterotomy should be performed to reduce the intraductal pressure. A percutaneous drain should be placed in the biloma.

Long term complications from cholecystectomies can be due to retained biliary stones, spilled stones, and port site hernias. Retained biliary stones can be present up to two years after a cholecystectomy. It can present with choledocholithiasis with hyperbilirubinemia and elevated alkaline phosphatase in the setting of a previous cholecystectomy. The treatment is ERCP and removal of the retained stone. Port site hernias can occur at any time. There is a low risk of bowel herniation, but omentum can become incarcerated and cause pain and infection. Patients need to return to the operating room to fix the port site herniation.

11.5.2 Postoperative Management

For patients undergoing uncomplicated elective operations, patients can be discharged home from the post-anesthesia care unit with scheduled follow up if tolerating oral intake and their pain is controlled. If patients have urgent or emergent operations or have concern for complicated operations, patients should be admitted overnight with oral pain medications and a general diet before discharge on postoperative day one.

References

1. Reynolds W Jr. The first laparoscopic cholecystectomy. JSLS-J Soc Laparoend. 2001 Jan;5(1):89.
2. Jackson PG, Evans SRT. Biliary System. In: Townsend CM, Beauchamp RD, Evers BM, Mattox KL, editors. Sabiston textbook of surgery E-book: Elsevier Health Sciences; 2016 Apr 22.
3. Keim V, Teich N, Fiedler F, Hartig W, Thiele G, Mössner J. A comparison of lipase and amylase in the diagnosis of acute pancreatitis in patients with abdominal pain. Pancreas. 1998 Jan;16(1):45–9.
4. Ismail OZ, Bhayana V. Lipase or amylase for the diagnosis of acute pancreatitis? Clin Biochem. 2017 Dec 1;50(18):1275–80.
5. "Veress Needle Technique." Zollinger's Atlas of Surgical Operations, 10e Eds. E. Christopher Ellison, and Robert M. Zollinger, Jr. New York, NY: McGraw-Hill.
6. Hasson Open Technique for Laparoscopi Access. In: Ellison E, Zollinger RM, Jr. eds. Zollinger's Atlas of Surgical Operations, 10e New York, NY: McGraw-Hill.
7. Litwin DE, Cahan MA. Laparoscopic cholecystectomy. Surg Clin North Am 2008 Dec; 88(6):1295–1313, ix.
8. Kim SS, Donahue TR. Laparoscopic cholecystectomy. JAMA. 2018 May 1;319(17):1834.