Chapter

Minimally Invasive Treatment for Cholelithiasis

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Abstract

Gallstone disease, cholecysto- and choledocho-lithiasis, is one of the most common digestive diseases. Most patients with symptomatic cholecystolithiasis are recommended to undergo cholecystectomy to alleviate their symptoms like abdominal pain and jaundice. Approximately 10–20% of patients who undergo cholecystectomy for gallstones have choledocholithiasis. Nowadays, endoscopic and/or laparoscopic approaches are widely accepted as the treatment for patients with gallstone. Patients with cholecystolithiasis are usually treated by laparoscopic cholecystectomy, whereas patients with choledocholithiasis are done by endoscopic sphincterotomy (EST) or laparoscopic common bile duct exploration (LCBDE). Additionally, some cases are treated by biliary reconstruction such as biliary enteric anastomosis. In this chapter, currently available laparoscopic approaches as a minimally invasive surgery are introduced and discussed on the basis of pathogenesis of the gallstone.

Keywords: minimal invasive surgery, laparoscopic cholecystectomy, lapatoscopic biliary enteric anastomosis

1. Introduction

Gallstone disease is one of the most common and popular diseases. The prevalence of this disease estimates to be approximately 10% of the adult population. Most patients are asymptomatic, but a certain percentage of patients are symptomatic. Operation of biliary tree including laparoscopic cholecystectomy are among the most common abdominal operative procedures.

2. Pathogenesis of gallstones

Gallstones are classified into cholesterol stone and pigment stone. Pathogenesis of cholesterol gallstone formation is considered to consist of three elements. First is biliary stasis, second is nucleation, and third is lithogenic bile (**Figure 1**) [1]. A cause of lithogenic bile has derived from cholesterol supersaturation. Aggregation of cholesterol-phospholipid vesicles is important to nucleation and formation of cholesterol-crystal. Biliary stasis in the gallbladder has been another factor associated with an increased incidence of cholelithiasis [2]. Pigmented stones are classified as either brown or black stones. Pathogenesis of pigmented stone is considered a result of infection [3].

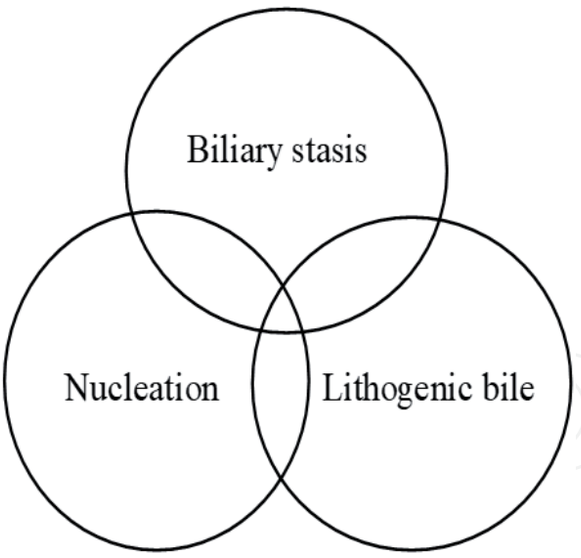

Figure 1.
Three factors of cholesterol gallstone formation.

3. Clinical manifestation

It is generally assumed that approximately more than half of all patients with gallstones are asymptomatic in the natural history. The remaining patients may have intermitted histories of biliary colic pain, or presenting with acute cholecystitis, symptom following to choledocholithiasis or gall stone pancreatitis. Of them, only small percentages of patients with symptomatic gallstone disease developed serious complication within a certain period [4]. One of potential risks of patients with gallstone disease is the development of gallbladder carcinoma [5, 6].

3.1 Acute cholecystitis

Acute inflammation of the gallbladder is the most frequent complication of gallstone disease. The initiating factor is the stone impaction either cystic duct or in the infundibulum of the gallbladder. It is frequently explored for intra-abdominal emergency, in particularly in middle-aged women and in the elderly. Approximately more than 50% of patients with acute cholecystitis have been bacteria in the bile culture, but these factors are thought to play a secondary role in the pathogenesis of cholecystitis. Bacteria typically isolated are of enteric origin, with the most common species being, *Escherichia coli*. Other bacteria may be present include Enterobacter, Klebsiella, or Enterococcus. Morphological changes of acute cholecystitis include, edema, hypervascularity, venous congestion, gallbladder distension.

3.2 Chronic cholecystitis

Whereas bacteria can be cultured from the bile of approximately more than 50% of patients with acute cholecystitis, the incidence of positive bile cultures in patients with chronic cholecystitis is less than 20%. In patients who have had recurring biliary colic pain with long-term gallstones, some of them had fibrosis and small round cell infiltration with the gallbladder wall thickening. Some patients with recurring biliary colic pain are thought histologically to have chronic cholecystitis.

4. Operative management of cholecystolithiasis

Historically, surgical technique of cholecystolithotomy, removing the gallstone from bladder and leaving the organ in the body, was firstly introduced by John Bobbs, an Indiana surgeon in the late 1800s. However, this procedure was not effective, because recurrence of symptom with the stone had occurred. Thereafter, open cholecystectomy (OC) had been introduced for gallstone disease by Karl Langenbuch, a German surgeon in 1882 [7]. Since then, this open surgery has become the gold standard for the management of patients with symptomatic gallstone over a 100 year. The introduction of laparoscopic cholecystectomy (LC) has revolutionized approach to patients with symptomatic gallstone disease in 1988 [8, 9]. This minimal invasive approach has soon emerged and spread world-widely for the patients with uncomplicated cholelithiasis and cholecystitis [10–12].

5. Laparoscopic cholecystectomy (LC)

5.1 Indications and contraindications of LC

The presence of symptomatic gallstones with biliary colic pain, intermittent right upper quadrant or epigastric pain, radiated pain with or without nausea and vomiting is the primary indication for LC. Complication of gallstones are acute cholecystitis, obstructive jaundice, and pancreatitis, is also indication of cholecystectomy. Patients with acute cholecystitis should be performed urgent LC within 72 hours. Patients with acute phase longer than 72 hours are likely to have a significant dense and inflammatory adhesion, so that some surgeons prefer to perform an initial conservative management of the disease, followed by scheduled interval cholecystectomy several week later.

Contraindication of LC includes suspicious case of gallbladder cancer, uncontrolled bleeding case, and no identified case of anatomical structure. Conversion to open laparotomy should consider in the cases of inability of definitive identification of surgical anatomy, or bleeding or bowel injury.

5.2 Anatomy

5.2.1 Hepato-cystic triangle and Calot's triangle

The hepato-cystic triangle is the space bordered by the inferior edge of the liver, the common hepatic duct, and the cystic duct of a gallbladder. The cystic artery passes through this space. The Calot's triangle is the bordered by the cystic duct, the cystic artery, and the common hepatic duct. It is important to obtain "the critical view of safety", which first described by Strasberg, et al. to avoid the common bile duct and hepatic duct injury during LC (**Figure 2**) [13].

5.3 Surgical procedure

5.3.1 Patient positioning

The patient is placed in the supine position on the operation table. The operation surgeon stands to the patient's left, scope holder to surgeon's left (British or American style) or between patient's legs (French or European style), and the assistant on the patient's right.

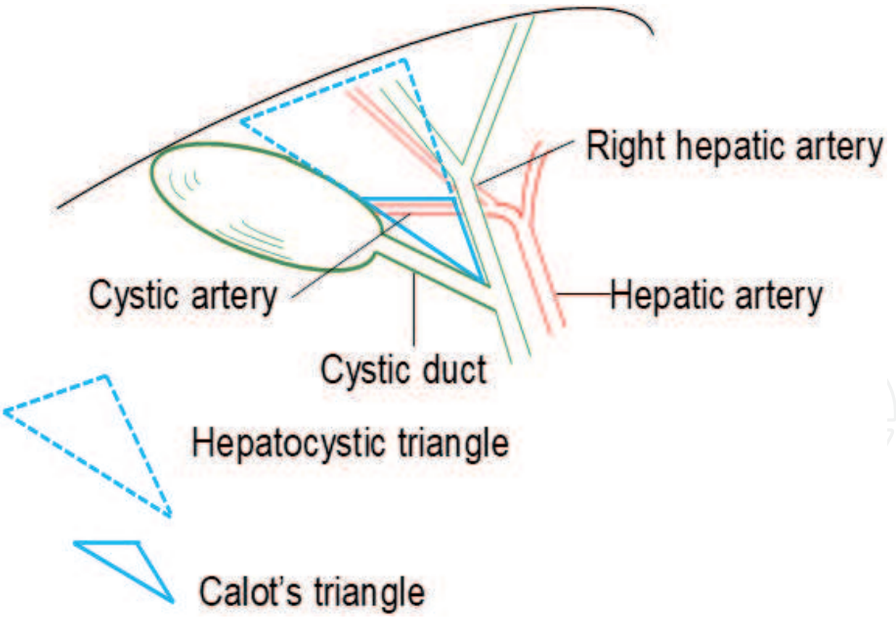

Figure 2.
Hepato-cystic triangle and Calot's triangle.

5.3.2 Port placement and pneumoperitoneum

The first 12 mm trocar is inserted through 10-15 mm incision through the umbilicus for the development of pneumoperitoneum as well as for the safe insertion of additional trocars under direct laparoscopic vision. Carbon dioxide has been used for the pneumoperitoneum in laparoscopic surgery. Abdominal pressure needs to be adjusted up to obtain adequate working-space, or down to limit the deleterious physiologic effects of the pneumoperitoneum. Abdominal pressure usually adjusts with range from 8 to 12 mmHg, avoiding a pressure about 15 mmHg. After pneumoperitoneum, laparoscope is placed through the umbilical trocar to confirm operative working space and insertion of the accessary trocars under laparoscopic view.

A total of four trocars are essential to perform a cholecystectomy. A trocar of 5 mm for grasping the fundus of the gallbladder is placed in the right anterior axillary line. A second port of 12 mm is placed high in the epigastrium, adjacent to the right of the falciform ligament. The fourth port of 5 mm is placed just below the liver edge in the right midclavicular line.

5.3.3 The dissection of the Calot's triangle

Dissection of the triangle of Calot's is the dangerous part of the operation. Critical view of safety is the important to avoid misorientation of the anatomy. A surgeon can be certain that cystic duct and cystic artery are identified only by achieving this critical view. Once identification of cystic duct, the duct is dissected only to allow the safe placement of two clips and division. Cystic artery is located cranial to the duct and usually runs paralleled to it. The cystic artery is related posterior to the sentinel lymph node, serving a useful landmark. The right hepatic artery can run very close to the gallbladder and can be easily misoriented for the cystic artery. After division of the cystic duct and artery, the gallbladder is then dissected from the liver bed. Appropriate direct- and counter-traction of gallbladder can help the gallbladder dissect from liver bed. The dissected gallbladder is extracted under direct vision through the umbilical trocar inserted site.

5.4 Complications of LC

Trocar injury to the bowel, mesentery, or vessels is care point of LC, but an insertion of the first trocar through 10-15 mm incision through the umbilicus can avoid these injuries.

A safe insertion of additional trocars under direct laparoscopic vision can also avoid these injuries. Bleeding from liver bed is among the complications. In most cases, bleeding from liver bed can be controlled with electrocautery. Bile leaks can be observed about 1% of LC cases after discharge hospital within 7 days. The cystic duct is the most common site and the bile duct is possible to occur. Once a bile leak is confirmed, percutaneous drainage and endoscopic sphincterotomy with stenting.

5.5 Advantages and disadvantages of LC

The advantages of LC are shown in **Table 1**. Postoperative pain is reduced by small size incisions of LC. The small size of the fascial incisions also allows quick return to surgical physical stress. The small incisions are also cosmetical benefits than the larger incisions of traditional open cholecystectomy. Magnified views achieved by a laparoscopy allow surgeons to inspect a precise anatomy. The patient can be recovered and discharged from the hospital and return to full activity within a few days.

However, there are several potential disadvantages of LC compared to OC (**Table 2**).

Laparoscopy has limitation of two-dimensional monocular image in contrast to three-dimensional depth perception. The operative field view is directed by a surgeon other than operator. It is more difficult to control significant hemorrhage using laparoscopy than in an open surgical view. Laparoscopic instrument has less tactile discrimination in contrast to direct digital palpation of OC. The

Less pain
Smaller incisions
Better cosmetics
Magnified view of anatomy
Earlier recover from surgical stress
Shorter hospital stay

Table 1.
Advantages of LC compared to OC.

Lack of three-dimensional perception
Views controlled by a scope holder
Control hemorrhage
Less tactile discrimination
CO_2 insufflation complication
Limit use of sever adhesion/inflammation case
Potential duct injury
Cost

Table 2.
Disadvantages of LC compared to OC.

pneumoperitoneum created by CO2 insufflation is sometimes associated with a patient systemic circulation. Generally, operation times is longer than for a conventional OC.

6. Choledocholithiasis

6.1 Pathogenesis and classification

Common bile duct stones have been noted in 10–19% of patients with cholelithiasis, and this incidence increases to about 80% with age over 90 years old [14]. Choledocholithiasis usually results from dropped stone of the gallbladder and passed through the cystic duct. These secondary bile duct stones are cholesterol stones in most cases and black stones in certain cases. These characteristic stones are formed in the presence of cholesterol saturation, nucleating factors, and biliary stasis. On the contrary, primary bile duct stones are associated with biliary stasis and infection of bacteria [15].

6.2 Clinical manifestation

Patients with choledocholithiasis may present with biliary colic, bile duct obstruction, bilirubinuria, pruritis, jaundice. Nausea and vomiting with intermittent or constant epigastric or right upper quadrant pain are occurred in cases of early phase of the biliary obstruction [16]. The clinical course may be complicated by acute gallstone pancreatitis, cholangitis, or rarely, hepatic abscess.

6.2.1 Cholangitis

Cholangitis is the most rapid fatal complication of gallstones and occurs resulting from biliary tree bacteria infection in the setting of biliary tree obstruction.

Bile duct obstruction including bile duct stone impaction results in decreased antibacterial defenses, allowing bacteria to gain access to the biliary tree. As biliary pressure rises with obstruction, bacteria with endotoxins leak into the systemic circulation and cause the sepsis [17]. Mortality of this condition approaches approximately 100% if the patients subject to needed drainage interventions [18]. Early diagnosis and immediate treatment are imperative for successful outcome.

6.2.2 Charcot's triad and Reynord's pentad

Fever, right upper quadrant pain, and jaundice is *Charcot's triad*, presenting in 50–70% of patients with cholangitis at presentation. Hypotension and altered mental status are known as *Reynold's pentad* in addition to Charcot's triad.

6.3 Treatment of cholangitis

Patients with cholangitis can become a severe condition in a short period of time, and rapid initiation of treatment is needed. Drainage of the biliary tree is the central of therapy for patients with acute cholangitis [17]. When biliary decompression by the drainage is not achieved, hepatic abscesses are unavoidable. Mortality approaches 100% in patients who are not subjected to needed drainage interventions after failure of conservative treatment [19]. Endoscopic retrograde cholangio-pancreatograph (ERCP) with bile duct clearance is a best choice of treatment of acute cholangitis and superior to the other drainage method including percutaneous transhepatic, and surgical drainage methods [20]. There are some endoscopic treatment options; The placement

of naso-biliary catheters or biliary stents to sphincterotomy and stone extraction. Sphincterotomy with bile duct clearance is preferred in patients with responded to antibody therapy.

7. Operative management of cholodocholithiasis

7.1 Minimally invasive surgery

7.1.1 Laparoscopic common bile duct exploration

7.1.1.1 Transcystic duct procedure

Trans-cystic duct procedure offers a good minimally invasive approach to CBD stones. This technique can effectively avoid a choledochotomy, resulting in the complexity of intracorporeal suture closure of the CBD. In the case of multiple stones, stone proximal to the cystic duct to bile duct junction, and fragile cystic duct, this technique is not preferable. Most trans-cystic duct procedure for CBD exploration require balloon dilatation of the cystic duct. Flexible biliary endoscopy with wired basket retrieval of calculi to be the safe technique due to direct vision of wired basket manipulation and stone capture [21].

The patient positioned and ports are set in the supine position similar to laparoscopic cholecystectomy. Guidewire is placed and positioned in cystic duct in preparation for advancing a balloon dilatation catheter for cystic duct dilatation. The balloon and cystic duct are observed laparoscopically for inflation of the balloon to the insufflation pressure recommended by the manufacturer. The cystic duct should never be dilated larger than the inner diameter of the CBD. Endoscopy can be inserted over a hydrophobic guidewire gently guided with an atraumatic grasper. After the endoscopy reaches in the cystic duct and the stone is seen and surrounded by the basket, it is gently closed and the stone and scope are withdrawn together [22]. The procedure is repeated until the duct is clear. After the completion of these processes, the cystic duct stump should be closed with a clip or a loop ligature.

7.1.1.2 Choledochotomy procedure

Choledochotomy technique is preferable in the case of a dilated CBD greater than 10 mm, calculi 10 mm or larger, multiple calculi, impacted stone, or stones proximal to the cystic duct to bile duct junction. It is contraindication in a not dilated CBD because of increase difficulty and the risk of stricture. The advantages of choledochotomy are the calculi can easily be irrigated out of the CBD and an endoscopy can be inserted bidirectionally distal and proximal to bile duct. The disadvantages of choledochotomy are considerable laparoscopic suturing technique needed to close the choledochotomy wound.

The anterior wall of the CBD is dissected sharply and bluntly caring for the multiple small vessels in the area. The choledochotomy should be created in the CBD below the cystic duct and the CBD junction. Two stay sutures are placed in the CBD area, which tent the anterior wall and prevent injury to the posterior wall on incising the CBD longitudinally. The length of choledochotomy should be the same as the circumference of the largest calculi to minimize the suturing needed for closure. Introduction of the choledochoscope is done through a subcostal trocar and inserted through the choledochotomy into the CBD. A biliary wire basket or balloon catheter is used to capture and remove calculi. After finishing complete clearance

of the CBD, it is possible to close the choledochotomy wound. However, concerning about large number of stones, recurrent stones, or remnant stones, surgical drainage of the CBD is needed. Surgical drainage includes T-tube drainage, choledocho-duodenostomy, or choledocho-jejunostomy.

7.1.2 Laparoscopic choledocho-duodenostomy

The common indications for choledocho-duodenostomy (CDD) are the benign diseases like impact stones with ERCP failure, retained stones, distal common bile duct stricture from chronic pancreatitis, recurrent choledocholithiasis [23, 24]. A laparoscopic CDD is typically performed by laparoscopic intracorporeal suturing, whereas a choledochojejunostomy (CJ) is done by stapled anastomosis. A CDD involves one anastomosis as compared with a CJ required as a Roux-Y limb or a jejunal loop. Another advantage of a CDD includes easy access to the biliary tree endoscopically and physiological bile drainage.

7.1.2.1 Choledochoduodenostomy procedure

The port setting for CDD is similar to the series used for a laparoscopic cholecystectomy. A flexible laparoscope or a 30-degree laparoscope is used through umbilical port. The anterior surface of the bile duct is sharply and bluntly dissected following longitudinal choledochotomy in the supra-pancreatic part of the CBD using microscissors. Incision should be made between 1.5 cm and 2.0 cm in length. After the removal of the stones, a generous Kocher's maneuver should be performed to mobilize the duodenum if needed. A longitudinal duodenostomy is made to prepare the anastomosis to the choledochotomy without tension. The posterior row of

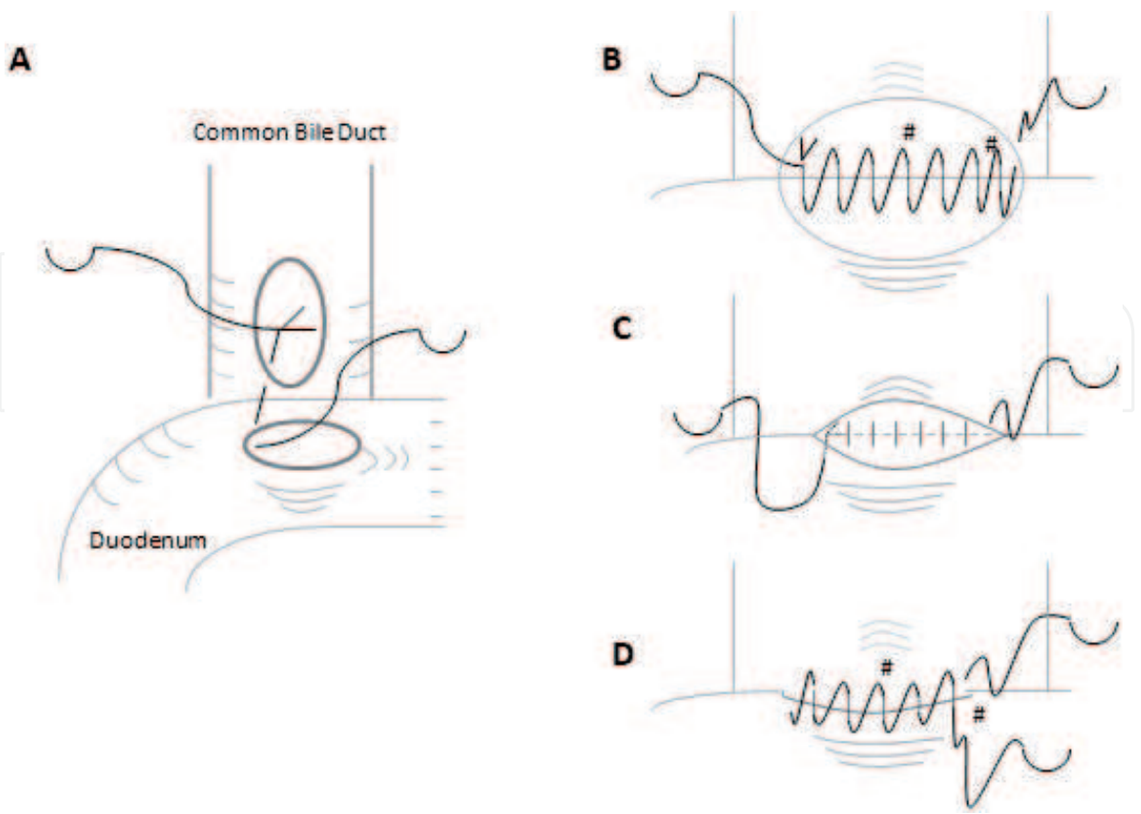

Figure 3.
Choledochoduodenostomy A, side-to-side anastomosis, B, posterior row of running suture, C, completion of posterior row suture, D, completion of anterior row running suture. # indicates placement of interlock suture. Originatd from Ref. [25].

sutures should be placed in a running fashion followed the anterior row sutures can be completed as the same fashion [25]. There are some discussions about whether a side-to-side or end-to-side anastomosis of the CDD is prefer in the laparoscopic surgery. The side-to-side anastomosis is used much often due to only requiring an anterior bile duct wall dissection. So-called "Sump syndrome" can occur with this anastomosis resulting from collecting debris or stones in distal bile duct. The end-to-side anastomosis has risks of ischemia and the stenosis due to poor blood supply of the distal bile duct (**Figure 3**).

7.1.3 Laparoscopic choledocho- or hepatioco-jejunostomy (CJ or HJ)

Laparoscopic choledocho- or hepatico-jejunostomy is a choice of biliary reconstructions when resection or exposure of the proximal bile duct or hepatic duct is required. Roux Y jejunal limb has to be created, resulting in making difficulty of the laparoscopic procedure. CJ or HJ is much advanced techniques, because of requirement of the two anastomosis of CJ or HJ with Roux-en-Y jejuno-jejunostomy.

7.1.3.1 CJ or HJ procedure

The patient is placed in supine position. The ports setting is according to laparoscopic cholecystectomy with some modification. A 5-10 mm port is added in the left mid-upper abdomen for suturing if necessary. In a case of the resection of the extrahepatic bile duct such as a choledochal cyst, CJ or HJ should be performed because of anastomosis tension free. After the careful dissection of the bile duct along the portal vein, the duct is encircled with taping for counter-traction. The duct is dissected up to a planned point toward the duodenum and the hepatic plate followed the division using a stapling device or endoloop. Once the bile duct has been prepared, the Roux jejunal limb is created by dividing the jejunum about 20-30 cm distal to Treitz ligament with stapler. Roux Y limb passes through antecolic route and creates a side-to-side or end-to-side jejuno-jejunostomy with a stapler. CJ or HJ is performed between the bile duct and jejunal small enterostomy using a running suture on both the posterior and anterior walls of the reconstructed jejunum in the end-to-side fashion.

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