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ADVANCES IN SURGERY

Elimination of Bile Duct Injury in Cholecystectomy

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Keywords

• Bile duct injury • Cholecystectomy • Laparoscopy • Gallbladder disease

Key points

- Laparoscopic cholecystectomy has been a remarkable advance in surgical care that has positively benefited millions of patients over the past 30 years.
- Although overall it is a safe operation, opportunities exist to reduce bile duct injury, which remains a priority for surgical quality improvement.
- The collective efforts of surgical societies to address this issue and the dissemination of safe operative management strategies and the development of consensus conference guidelines have the potential to make this operation even safer in the future.

INTRODUCTION

Gallbladder disease is common in the general adult population [1,2], making cholecystectomy one of the most commonly performed procedures in the United States and worldwide [3]. Early after its introduction in the late 1980s, laparoscopic cholecystectomy became the standard of care due to its advantages of reduced pain and hospital length of stay, reduced general complications (wound and cardiopulmonary), faster return to activity, lower costs, and increased patient satisfaction [4–6]. Although it is considered a safe procedure, complications still occur in approximately 5% to 6% of patients [7].

Bile duct injury (BDI) remains the most dreaded complication after laparoscopic cholecystectomy. Previous data report an incidence of 0.2% of BDI during the era of open cholecystectomy [8] and significantly higher for

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laparoscopic cholecystectomy [9]. In 2001, a survey questionnaire from the American College of Surgeons completed by practicing surgeons reported 34% of the responders self-reported a BDI [9]. Although its incidence has improved since laparoscopy was first introduced, studies have described an incidence ranging from 0.08% to 0.4%, depending on the definition of BDI [10–13]. One of the largest studies examining BDI comes from prospectively collected data from the Swedish National Quality Registry of Gallstone Surgery and Endoscopic Retrograde Cholangiopancreatography (GallRiks), which was established in 2005. This registry, which captures approximately 90% of all cholecystectomies in Sweden, examined 51,041 cholecystectomies and reported an overall incidence of BDI incidence of 1.5% (including bile duct leaks) and 0.4% incidence of major BDIs that required reconstruction [13]. Other administrative database studies and systematic reviews from the past 5 years have shown major BDI rates of 0.15% to 0.3% [10,14–17]. In the United States, where up to 1,000,000 cholecystectomies are performed annually, this translates into 2500 to 3000 BDIs per year.

BDI is a devastating and potentially life-threatening event that has been associated with other complications and the necessity for other procedures/interventions, lower quality of life, disability, higher mortality, and litigation [18,19]. Complications include biliary fistula, infection, and biliary obstruction. Studies have shown both increased short-term and long-term mortality due to BDI [20–23]. Pitt and colleagues [22] reviewed a single-institution experience of 528 patients with BDIs and reported a 2.4% mortality rate within 3 months of intervention after the injury. A study in 2013 examining 1083 cholecystectomies reported a BDI rate of 0.1% and an all-cause mortality rate of 0.8%. The attributed BDI mortality was 0.2% [21]. Halbert and colleagues [23] examined 156,958 laparoscopic cholecystectomies performed between 2005 and 2010. In this analysis, 125 patients with common bile duct (CBD) injury required further reconstruction. No 30-day mortality was observed; however, all-cause mortality was 20.8%, which was 8.8% above the cohort's expected age-adjusted rate of death. A more recent study examined 800 patients referred to a tertiary center after a BDI. The mean survival after BDI was 17.6 years and BDI-related mortality was 3.5% (28/800), because patients treated surgically had significantly higher survival. Finally, BDI patients reported a significantly worse physical quality of life, worse disease-specific quality of life, and higher loss of productivity compared with a control group and had a higher rate of disability [20].

BDI also has been associated with a significant economic health care burden, with reported total costs due to this complication surpassing $1 billion annually [19]. BDI remains a key source of malpractice claims against surgeons and is the most common reason for litigation against general surgeons [24]. Because BDI is associated with significant adverse effects on patient lives and is a contributor to increased health care costs, prevention of this complication is of high importance and strategies for minimizing BDIs have become a top priority for quality improvement in general surgery.

ETIOLOGY AND RISK FACTORS

BDIs can be classified as major and minor. Major injuries are those that require biliary reconstruction whereas minor injuries include bile leaks and tangential BDIs, most of which can be managed endoscopically. The GallRiks national registry for cholecystectomies in Sweden identified 747 BDIs among 51,041 patients performed between 2005 and 2010. A majority of the injuries were Hanover grade A1 (cystic duct leak, 35.5%), followed by a Hanover grade C1, C2, or C3 (tangential lesion in the CBD, 17.4%) [25].

One way to classify these injuries is by the Strasberg classification, which is a modification of the Bismuth classification and allows precise differentiation between small and serious injuries performed during laparoscopic cholecystectomy and the level of injury [26]. Types A, B, C, and D injuries are those that result in a bile leak without transection whereas type E injuries are those in which the main bile duct is completely transected and are classified by severity from E1 to E5. The etiology and mechanism of biliary injury may be multifactorial and includes aberrant biliary anatomy, acute or chronic inflammation in the hepatocystic triangle, technical factors, and misidentification of anatomy. Way and colleagues [27] in a landmark 2003 study evaluated the causes of BDI in 252 laparoscopic cholecystectomies. The investigators used operative, pathology and radiology reports and reviewed unedited videos of the procedures. BDIs were classified by the Stewart-Way classification. The primary cause was a visual perceptual illusion in which the surgeon believes the cystic duct is being dissected when in fact it is the CBD. Faults in technical skills were identified as the primary mechanism of injury in only 3% of cases.

Dissection during laparoscopic cholecystectomy should be performed gently and electrosurgery should be used carefully with short activations (2–3 s) to avoid thermal injuries. One common mistake is to start the dissection too low, which can endanger the bile duct and porta hepatis and can lead to misperception of biliary anatomy. In addition, retraction of the gallbladder is important because the fundus should be retracted cephalad, whereas the infundibulum should be retracted laterally and slightly caudal to avoid parallel alignment of the cystic duct with the CBD. The critical view of safety (CVS) is recommended for secure identification of structures to minimize the risk of a misidentification injury. Anatomic situational awareness also is important in limiting the risk of injury. Both of these aspects of safe cholecystectomy are discussed in further detail later.

CONDITIONS ASSOCIATED WITH THE DIFFICULT GALLBLADDER

Several conditions have been associated with increased difficulty of cholecystectomy that include acute cholecystitis, severe chronic cholecystitis (especially a shrunken, contracted gallbladder), obesity, Mirizzi syndrome, and cirrhosis. Obese patients may be more difficult due to difficulty in lifting the gallbladder to expose the hepatocystic triangle due to a bulky, fatty liver; omentum that hinders the exposure; and intrahepatic position of the GB. In such cases, placement of a fifth port in the right midabdomen for a retractor to displace the omentum

inferiorly may be helpful. Both severe acute and/or chronic inflammation may obscure the anatomy and result in biliary inflammatory fusion of the cystic structures and neck of the gallbladder to the CBD and right hepatic artery, which can make it difficult or dangerous to obtain the CVS. Mirizzi syndrome consists of a large stone impacted in the gallbladder neck that causes partial obstruction of the CBD. In such cases, there often is considerable inflammation in the area, and surgeons should be aware of the potential for a fistula between the gallbladder and the bile duct. As a result, these patients are best managed in a center with expertise in difficult cholecystectomy and available interventional endoscopy.

Acute cholecystitis and timing of cholecystectomy

Acute cholecystitis is the most common condition that increases the difficulty of cholecystectomy. Several randomized controlled trials have examined the timing of surgery after presentation with acute cholecystitis with respect to early versus delayed cholecystectomy. In a study from Roulin and colleagues [28], early cholecystectomy was defined as performed after the index hospital admission, whereas delayed cholecystectomy was performed at least 6 weeks after initial antibiotic treatment. The investigators concluded that early cholecystectomy even beyond 72 hours of symptoms was safe and associated with less overall morbidity, cost, and hospital length of stay. Gutt and colleagues [29] in a study of 618 patients reported that morbidity was significantly lower in the immediate cholecystectomy group (11.8% vs 34.4%), although conversion rates and mortality did not differ between the 2 groups. Hospital costs and mean length of stay also were lower in the early group. A meta-analysis published in 2015 found that early laparoscopic cholecystectomy was associated with decreased wound infections, shorter length of stay and decreased costs, lower rates of BDIs and leaks, and lower rates of conversion to open cholecystectomy [30]. In none of these studies was the severity of the cholecystitis graded according to the Tokyo guidelines or other severity criteria. Nonetheless, it is generally recommended that in patients with acute cholecystitis who are acceptable risk candidates for surgery, laparoscopic cholecystectomy be performed early (<72 hours) after the onset of symptoms rather than later in the course.

STRATEGIES FOR REDUCING BILIARY INJURY

Despite description of the CVS more than 20 years ago and numerous publications on BDI and cholecystectomy, the problem continues to occur. In 2014, the Society of Gastrointestinal and Endoscopic Surgeons (SAGES) formed the Safe Cholecystectomy Task Force, with the goal of enhancing a culture of safety around this operation. A nominal group consensus technique was used to survey 160 surgeons to identify key domains important to safe dissection [31]. The result from this effort was development of a 6-step program of strategies that can be used by surgeons intraoperatively, described in detail later. SAGES also has recently published online a series of 12 educational modules that provide more depth to the topic and are freely available to the surgical community (fesdidactic.org).

Recently, a multisociety consensus conference sponsored by SAGES, the Americas Hepato-Pancreato-Biliary Association, International Hepato-Pancreato-Biliary Association, Society for Surgery of the Alimentary Tract, and European Association for Endoscopic Surgery on prevention of BDI in cholecystectomy was held to develop evidence-based practice recommendations and guidelines on this topic. In addition, priorities for future studies to address unanswered questions in the field also were formulated. The recommendations from the consensus meeting are available for viewing at www.preventbdi.org and will be published in the coming year.

The 6 steps in the SAGES program are as follows:

1. Use of the CVS for the identification of the cystic duct and artery
2. Awareness of the potential for aberrant anatomy
3. Liberal use of intraoperative cholangiography (IOC) or other methods for identification of structures
4. The use of an intraoperative time-out or pause during the procedure prior to clipping, cutting, or transecting the cystic duct or cystic artery to verify the anatomy
5. Recognizing when it is not safe to proceed if the dissection is entering a zone of danger and considering the need to alter the approach
6. Getting help from another surgeon if needed

Step 1: use of the critical view of safety

The CVS, first introduced in 1995 by Strasberg and colleagues [26], has 3 requirements (Fig. 1).

1. The hepatocystic triangle, which is defined as the triangle formed by the cystic duct, the common hepatic duct (CHD), and the inferior edge of the liver, should be cleared of fat and fibrous tissue.
2. The cystic plate should be exposed in such a manner that the lower third of the gallbladder is separated from the liver.
3. Only 2 structures, the cystic duct and cystic artery, should be visualized to enter the gallbladder.

The CVS method of identification has been the approach most accepted by surgeons around the world during laparoscopic cholecystectomy [32,33]. Although there are no direct comparisons or randomized controlled trials of using the CVS versus other methods, such as the infundibular or top-down techniques, several lines of indirect evidence suggest that the use of the CVS reduces BDI. Several large cohort studies have reported no or lower BDIs while using the CVS, [32,34,35]. The largest study, by Palanivelu and colleagues [34], examined a total of 9864 laparoscopic cholecystectomies and reported a BDI rate of 0.07%. In addition, case series studies of BDIs with analysis of the mechanism of injury using either intraoperative reports or video review indicate that the method of anatomic identification was nearly always something other than the use of the CVS [36–38]. The largest such study [39] comes from the Netherlands and encompasses 800 BDIs, of which 528

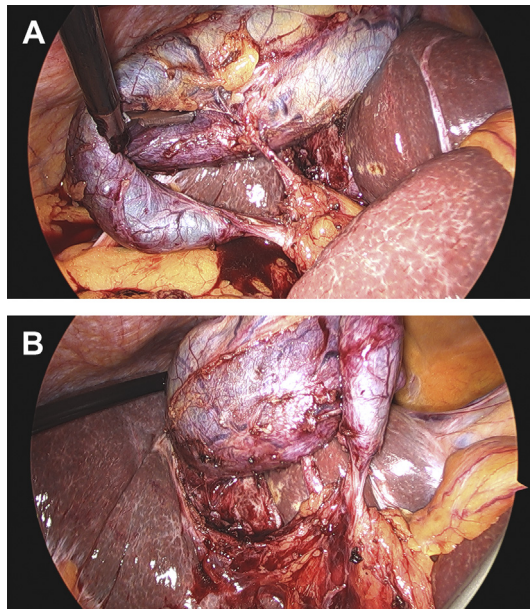

Fig. 1. Operative photograph of the CVS during laparoscopic cholecystectomy. Shown are the (*A*) anterior view and (*B*) posterior lateral view. Confirmation of the CVS should be made from both viewpoints.

operative reports were available. The CVS technique was reported in only 33 patients (6.3%) [39].

In another study of 1108 cases of laparoscopic cholecystectomy [37], 65 cases with complications underwent video review. Operative notes in these cases stated that the CVS was achieved in 80% when in fact it was reached in only 10.8%. Importantly, the CVS was not used in any of the cases of identified BDIs. In addition, because this technique was been introduced in 1995, only 1 report of a BDI using this technique has reported; however, the exact mechanism of BDI was unclear [37]. The Dutch Society of Surgery has now recommended that all surgeons use the CVS method of identification routinely during cholecystectomy [39]. Studies also suggest that the CVS is incompletely understood or not applied appropriately in many circumstances. Deal and colleagues [40] extracted 160 video cases of laparoscopic cholecystectomy from the internet and scored them both by expert surgeons and crowd workers according to published criteria for achievement of the CVS. They found an average CVS score of 3.6 (1–6 scale) and only 12.5% of videod cases achieved a CVS score greater than or equal to 5, which indicates considerable room for improvement [40].

Step 2: understanding normal and aberrant anatomy

Variations in biliary anatomy are common and are important considerations in reducing the risk of biliary injury. The hepatocystic triangle is bounded by the

cystic duct, CHD, and the liver. Most commonly, the cystic artery is medial to the cystic duct and arises from the right hepatic artery, which commonly crosses posteriorly to the bile duct. The right hepatic artery may have a hump, which lies close to the gallbladder wall and may be vulnerable to injury if the dissection is too posterior. The cystic duct can be short due to inflammation and fibrosis and can have a variable course and path of entry into the CBD.

Variations in right hepatic duct anatomy are especially common and include separate entries of the anterior and posterior sectoral ducts into the CHD, low insertion of the right posterior duct on the CHD, and insertion of the cystic duct directly into the right hepatic duct (2%). The cystic duct may have a lateral, medial, or posterior entry into the CHD and may run parallel to it for a variable distance before entering it (Fig. 2). Rouviere sulcus is a fissure in the right lobe of the liver in which the right port pedicle runs and which demarcates the plane of the porta hepatis (Fig. 3). The dissection, therefore, always should stay anteriorly to Rouviere sulcus. The CBD also has an epicholedochal plexus on it which can help distinguish it from the cystic duct. Finally, a clue that the dissection may be on the CBD instead of the cystic duct is when the dissection is taking place in close proximity to the duodenum. A more detailed review of anatomy is available in the SAGES safe cholecystectomy modules (www.fesdidactic.org).

Step 3: role of intraoperative imaging to enhance identification of structures (cholangiogram, ultrasound, and intraoperative cholangiography)

IOC should be considered an integral tool in a surgeon's armamentarium when undertaking cholecystectomy, whether laparoscopic or open. Surgeons should

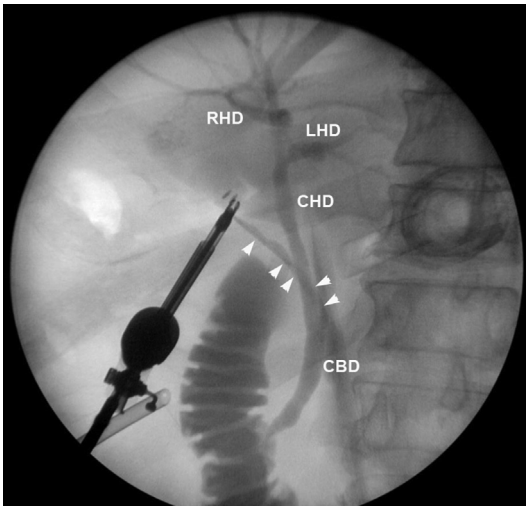

Fig. 2. IOC with parallel cystic duct (*arrowheads*). LHD, left hepatic duct; RHD, right hepatic duct. Note no filling defects and normal filling of duodenum with contrast.

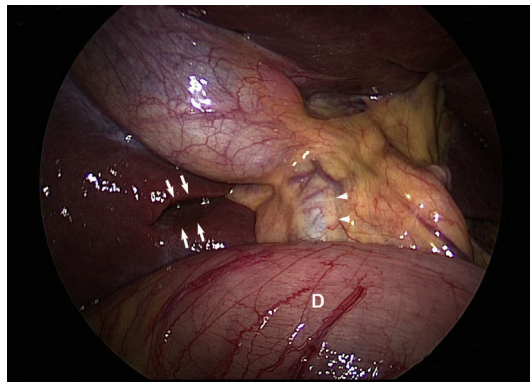

Fig. 3. Laparoscopic view of the gallbladder and Rouviere sulcus (*arrows*), which marks the plane of the porta hepatis. Note also the CBD (*arrowheads*) with epicholedochal plexus and proximity of duodenum (D) to the CBD.

be comfortable not only with the technique of IOC but also with the ability to accurately interpret the images. Since its introduction in the 1930s [41], the benefits of IOC have been debated. Many investigators advocate the routine use of IOC [11,42,43], although selective use has been advised as well and is practiced more commonly [44]. A study in 2002 reported a use of IOC during laparoscopic cholecystectomy in 44.6% of cases [45] and more recently a population study showed a decreasing rate of use of IOC with rates of utilization of IOC of 10% to 12% per year. This decrease in utilization of IOC raises the issue of adequacy of training in residency with its use and interpretation [25,43].

The use of IOC is controversial, because opponents consider it time consuming, cumbersome, and subject to misinterpretation or false-positive findings regarding the presence of CBD stones and without a clear impact of the risk of biliary injury [46,47]. Evidence from several large administrative database studies suggest, however, a benefit of reduction in BDI with IOC use [13,25,43,48–50] whereas others do not [15,46]. These studies are limited by a lack of detail regarding the reasons for IOC use and other variables, which make them at high risk of bias. When properly interpreted, however, IOC has been associated with increased intraoperative recognition of injury, which may decrease the severity of injury and avoid transection or excision of a portion of the duct. A systematic review of 8 randomized controlled trials showed no level 1 evidence for or against the use of IOC. Most of these trials were small, however, with few biliary injuries and were not sufficiently powered to answer the question in terms of biliary injury [51].

Buddingh and colleagues [39] performed a systematic review of articles examining several imaging techniques for prevention of BDI during laparoscopic cholecystectomy. The investigators concluded that IOC or laparoscopic ultrasound is recommended to be performed routinely. In the GallRiks Swedish database of 51,404 cholecystectomies, multivariable analysis showed that use of IOC was

protective for BDI in acute cholecystitis and a history of acute cholecystitis only [13]. Another study from GallRiks found that routine IOC use was associated with a reduction in mortality during cholecystectomy [13] These findings highlight the importance of intraoperative imaging in potentially difficult cases.

Laparoscopic ultrasonography and fluorescent cholangiography are other methods for visualization during laparoscopic cholecystectomy. Compared with IOC, laparoscopic ultrasonography is not associated with radiation and is less time consuming. Studies have shown good fidelity with laparoscopic intraoperative ultrasound in identification of biliary anatomy. A disadvantage is that most surgeons have not been adequately trained with its use and interpretation, so its value is highly operator dependent [52,53].

Near-infrared fluorescent cholangiography was first described in 2009. It uses an injection of indocyanine green, which is excreted into bile and emits light with a peak wavelength of 830 nm when illuminated with near-infrared light (Fig. 4). This technique has reported rates of visualization of 71.4% to 100% for the cystic duct, 33.3% to 100% for the CHD, 25% to 100% for the cystic duct/CHD junction, and 50% to 100% for the CBD [47]. An advantage of this modality is that it can be used repeatedly throughout the procedure, that is, continuously mapping biliary anatomy, and is easy to perform technically. Although it can potentially help with identification of structures during laparoscopic cholecystectomy, data are insufficient to assess its role in higher risk patients (eg obesity and acute cholecystitis) and regarding its impact on biliary injury. Two prospective trials (NCT02558556 and NCT02702843) currently are ongoing to assess its value during cholecystectomy.

Step 4: intraoperative time-out

Intraoperative time-out or a stop point should be considered at any point in the dissection if the anatomy is unclear and before clipping or cutting of the cystic duct and artery. The purpose of this step is to encourage a mindful pause, to step back and take a fresh look at the field and verify that the anatomic perceptions of the anatomy is accurate. Although there are no data to support this

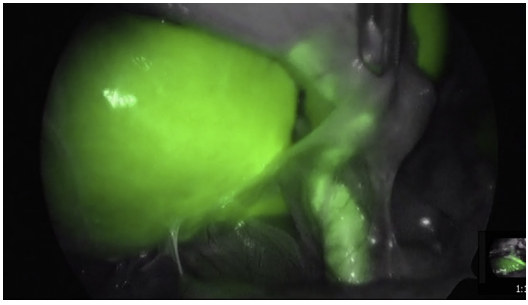

Fig. 4. The use of indocyanine green showing the CBD with the bright green fluorescence background of the liver. Some fluorescence also is seen in the cystic duct. (*Courtesy of* A. Pryor, MD, Centereach, NY.)

approach specifically in laparoscopic cholecystectomy, this step is in alignment with principles that have derived from studies of surgical checklists and the time-out done to minimize wrong site surgery and other safety checks in the operative environment.

Step 5: bailout options (when the dissection and conditions in the hepatocystic triangle are difficult and potentially dangerous)

Surgical decision making plays a critically important role in managing difficult gallbladder scenarios. In those cases in which the dissection has stalled, the CVS cannot be obtained because of severe inflammation, or the anatomy is uncertain, consideration should be given to one of several alternative or bailout options, as listed in Box 1.

Conversion to open cholecystectomy

Historically, conversion to open cholecystectomy has been the default bailout option because it may allow for better exposure and enhanced ability to palpate, or feel, the tissues. The decision to convert to open should factor in background and experience performing open cholecystectomy as well as comfort with laparoscopic bailout options. It also should be noted that a difficult laparoscopic cholecystectomy usually remains a difficult open cholecystectomy, and there are instances of biliary injuries that have occurred after conversion from laparoscopic to open [54]. Moreover, many of the recent generation of trainees have had limited experience with open cholecystectomy, especially in difficult cases.

There are several situations where conversion to open may be appropriate besides a difficult dissection. These include hemodynamic instability due to pneumoperitoneum (a rare event), inability to visualize the anatomy through a laparoscopic approach, uncontrolled bleeding, adherent colon or duodenum to gallbladder, suspected gallbladder cancer, and management of numerous bile duct stones that are not amenable to endoscopic retrograde cholangiopancreatography.

Aborting the operation

Rarely, it may be necessary or advisable to abort the operation altogether. Such circumstances include instability of the patient or hemodynamic instability or inability to identify the gallbladder, due to inflammation or dense omental pack or adhesions. This setting also is a situation in which calling for help would be advisable.

Box 1: Bailout options for difficult anatomy

Conversion to open cholecystectomy
Aborting the operation
Cholecystostomy tube drainage (surgical or percutaneous)
Subtotal cholecystectomy
Help from another surgeon/transfer to tertiary center

Cholecystostomy tube drainage

Percutaneous cholecystostomy tube (PCT) is a minimally invasive procedure that can be used as the initial treatment in the critically ill, elderly, or high-risk patients presenting with acute cholecystitis who are not candidates for surgery or those with severe cholecystitis. It can be definitive management in some cases or as a bridging procedure to eventual cholecystectomy. Yeo and colleagues [55] examined 103 patients who received PCT; 41% underwent eventual cholecystectomy with a conversion rate of 15%. Major postoperative complications were described in 5% of the patients, with the investigators reporting 1 BDI. Another study using the New York SPARCS administrative database examined outcomes of 9738 patients. The rate of cholecystectomy after PCT increased from 25% in 2000 to 31.7% in 2012. Of the patients who underwent cholecystectomy after PCT, 47 experienced a major BDI requiring intervention (1.57%), which is significantly higher than the reported rate of BDI during laparoscopic cholecystectomy of 0.2% to 0.4% [56]. Thus, it is important to recognize that subsequent cholecystectomy after PCT often is a more technically challenging procedure. Surgical cholecystostomy tube drainage also may be used intraoperatively if on exploration conditions are deemed too difficult to proceed safely with the dissection. A Foley-type catheter may simply be placed in the dome of the gallbladder and secured in place with a purse-string suture.

Subtotal cholecystectomy

Subtotal cholecystectomy is another bailout method that is gaining interest and can be done laparoscopically or open. Indications to consider subtotal cholecystectomy are a densely inflamed or fused hepatocystic triangle and inability to obtain the CVS (Fig. 5). In this procedure, the gallbladder is opened just above

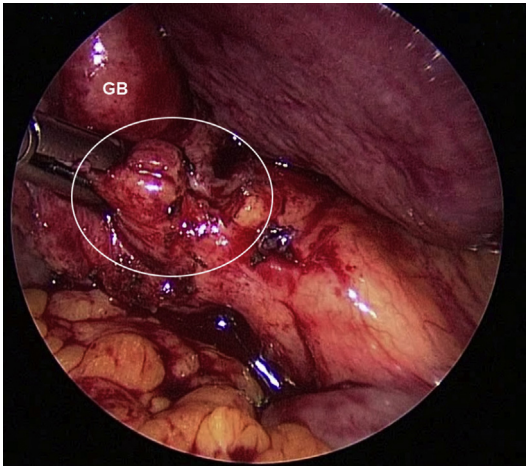

Fig. 5. Difficult inflamed gallbladder with inflammatory fusion of the hepatocystic triangle (circled). In this scenario, a bailout option should be considered (eg, fenestrating subtotal cholecystectomy). GB, body of gallbladder.

the neck, which allows a shield or cuff of gallbladder to protect the critical structures in the area of dense inflammation in the hepatocystic triangle. All stones are removed along with the front and side walls of the gallbladder. If deemed feasible, the entire back wall of the gallbladder can be removed as well. A cholangiogram may be done through the cystic duct orifice to confirm the anatomy and exclude residual cystic or CBD stones. If visible, the cystic duct orifice may be closed from the inside the gallbladder with a suture.

Recently, subtotal cholecystectomy has been defined into 2 subtypes: fenestrating subtotal cholecystectomy and reconstituting subtotal cholecystectomy [57]. In fenestrating subtotal cholecystectomy, the neck of the gallbladder is left open whereas in the reconstituting method it is closed either by suturing or stapling across it, which reconstitutes a small gallbladder remnant [57]. As a result, the reconstituting type is associated with an increased risk of recurrent stones, symptoms, and reoperation. For this reason, fenestrating subtotal cholecystectomy is the preferred procedure although it is associated with a higher rate of bile leakage; however, the bile leaks usually either resolve or can be managed by endoscopic retrograde cholangiopancreatography and stent placement [58]. Regardless of the approach, a closed suction drain should be left in place until the drainage is clear and the patient is tolerating a diet. Several systematic reviews describe these techniques as safe procedure [59,60]. Surgeons should consider their own expertise, however, in deciding which of these bailout options to use in a given patient.

Step 6: getting help from another surgeon when conditions are difficult

Another principle of safe cholecystectomy is that surgeons should have a low threshold for calling for help from another surgeon when feasible to do so. Conditions in which help might be called for are similar to those under which conversion to open operation or another bailout option is considered, as described previously, or when an experienced or higher-level assistant is needed. Calling for help is a sign of good judgment and should be considered liberally, especially early in a practice. In many practices, calling another surgeon is not always feasible and depends on the local hospital and surgical environment. Another help option if a surgeon is uncertain what to do and no immediate help is available is to call a referral center to discuss the operative scenario with an experienced surgeon in the field.

SUSPECTED BILE DUCT INJURY

If a BDI is suspected or confirmed in the operating room, it is critical to minimize the consequences and avoid extending the injury. If the anatomy is unclear, consideration should be given to performing an IOC or other imaging modality (US or near-infrared cholangiography). The IOC can be done through the neck of the gallbladder or putative cystic duct or divided ductal structure if present. Converting to open operation should be avoided unless there is local expertise to repair the injury or associated bleeding that cannot be controlled because this may complicate subsequent repair. Calling for

help from another surgeon not only may help clarify the situation but also provide an unbiased perspective on the circumstances at hand.

If a major BDI is evident, it is important to acknowledge that the best outcomes of repair are by surgeons experienced in biliary reconstruction [61,62]. If such expertise is not locally available, it is best to leave a closed suction drain in place to control bile leakage and expeditiously transfer the patient to a center with advanced hepato-pancreato-biliary surgeons. The role of advanced endoscopic and interventional radiology support is also crucial to a successful outcome in this setting.

SUMMARY

Laparoscopic cholecystectomy has been a remarkable advance in surgical care that has benefited millions of patients positively over the past 30 years. Although overall it is a safe operation, opportunities exist to reduce BDI, which remains a priority for surgical quality improvement. The collective efforts of surgical societies to address this issue and the dissemination of safe operative management strategies and development of consensus conference guidelines have the potential to make this operation even safer in the future.

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