

Prevention of Common Bile Duct Injuries in Laparoscopic Cholecystectomy

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ABSTRACT

Despite advancement in training and technology since its introduction, more than 20 years ago, bile duct injuries continue to be two to three times more common than in open surgery causing significant morbidity and mortality. Hence, a review of the literature present on the internet on bile duct injuries in laparoscopic cholecystectomy was performed to review the causes of biliary injury and methods of prevention of such mishaps. There was a general consensus that careful dissection and correct interpretation of the anatomy avoids the complication of bile duct injury during cholecystectomy. Routine intraoperative cholangiography is associated with a lower incidence and early recognition of bile duct injury. A low threshold to conversion to open approach in case of uncertainty was also advocated.

Keywords: CBD injury, Complication of laparoscopic cholecystectomy, Common bile duct injury.

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INTRODUCTION

Since its introduction by Erich Muhe in 1985, laparoscopic cholecystectomy has gained worldwide acceptance within a short period of time to become the gold standard treatment for cholelithiasis.¹ However, along with all the advantages subsequent upon a minimal invasive procedure, came the inherent drawbacks of performing surgery in a new and unfamiliar way. The incidence of bile duct injuries were definitely increased compared with the open technique.² Subsequent improvements in the equipment and refinement in technique, as well as improved training in the laparoscopy, resulted in a progressive decrease of the incidence of these injuries. Nevertheless, global incidence of CBD injury has remained fairly constant around 0.5%, as reported by various meta-analyses studies over a 15-year period.³ In the United States, 34 to 49% of surgeons have caused a major bile duct injury with an individual experience of one to two such cases.⁴ Increasing evidence suggests that such injury should be managed by an experienced hepatobiliary surgeon and that early recognition of injury directly affects outcome. Furthermore, it continues to be two to three times more common compared with published major bile duct injury rates for open cholecystectomy which

indicates that this is still an incompletely resolved problem.^{5,6}

The problem is especially highlighted as patients sustaining a bile duct injury (BDI) during cholecystectomy have an impaired quality of life. Bile duct injuries often necessitate several invasive procedures and subsequent operations causing fear and anxiety to patients as well as surgeons. Studies show that such patients continue to have a higher risk of dying as compared with those who have an uncomplicated cholecystectomy.⁷ There is a significant increase in healthcare expenses associated with the complication and this is a common reason for medical malpractice litigation.

AIM

This article aims to review the causes of biliary injury and methods of prevention of such mishaps.

MATERIALS AND METHODS

A literature search was performed using internet with medical search engines Pubmed, Medscape using the keywords—bile duct injuries in laparoscopic cholecystectomy, prevention of bile duct injuries. The articles obtained were then reviewed using the broad categories of risk factors for BDI, classification of BDI and methods of prevention.

DISCUSSION

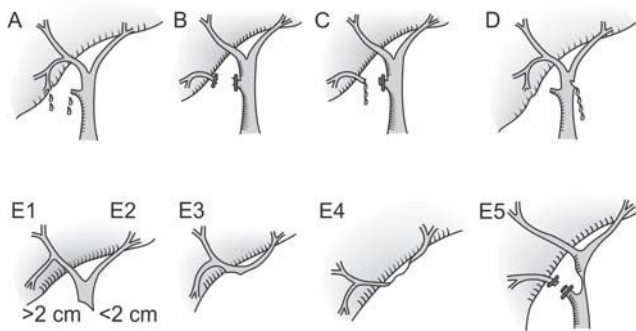
Classification of Bile Duct Injuries

The traditional Bismuth classification was modified in 1995 by Strasberg et al broadening the details to separately identify those injuries seen with increased frequency during laparoscopic cholecystectomy (Figs 1A to E5).² This classification, based on anatomic location and severity, is widely used currently.

RISK FACTORS FOR BILE DUCT INJURIES

Training and Experience

Early reports obtained in the 1990s, suggested that the high injury rates were due in part to the inexperience in this new procedure. This was called the 'learning curve effect'.⁸ A decrease in the frequency of BDI was therefore expected



Figs 1A to E5: Classification of laparoscopic injuries to the biliary tract²

as surgeons progressed beyond the learning curve. However, more than 20 years after the introduction of the procedure, with dramatic advancement in training and technology, there is still no evidence of any remarkable improvement. Hence, other factors besides the inexperience have to be considered. Although most injuries occur within the surgeon's first 100 laparoscopic cholecystectomies, one-third happen after the surgeon has performed more than 200 showing that it is more than inexperience that leads to bile duct injury.⁴

Disease Severity

Severity of the underlying disease process has been proved to be an important risk factor. As in its open counterpart, biliary injuries are more likely to occur during difficult laparoscopic cholecystectomies.⁹ Laparoscopic cholecystectomy performed for acute cholecystitis has a three times more likelihood of causing a biliary injury than an elective laparoscopic case, compared with a two-fold increased incidence in open cholecystectomy for acute cholecystitis.¹⁰ Ooi et al reported a retrospective review of 4,445 laparoscopic cholecystectomies with 19 biliary injuries (0.43%). They found that inflammation at Calot's triangle was an important associated factor for injury.¹¹ Other mentioned risk factors include old age and male gender.

Anomalous Anatomy

As in any biliary surgery, this is a common cause of error, especially in laparoscopic surgery. The aberrant right hepatic duct anomaly is the most common problem leading to an injury. Injury to aberrant right hepatic ducts during laparoscopic cholecystectomy has been reported in various studies.¹² However more often, such injuries are underreported as occlusion of an aberrant duct may remain asymptomatic. Such aberrant ducts seem especially vulnerable during laparoscopic cholecystectomy.²

Direct causes of Laparoscopic Biliary Injuries

Misidentification Errors

The most serious injuries are known to be caused by misidentification of anatomy. It has been suggested that the commonest cause of common bile duct injury is misidentification of biliary anatomy (70-80%).⁶ There are two main types of misidentification. In the first scenario, the common duct is mistaken for the cystic duct, and is occluded and divided. Subsequently, the bile duct must be divided again later in the dissection during removal of gallbladder, usually reported to as a 'second cystic duct' or 'accessory duct'. An E1 to E4 injury results, depending on the level of the second biliary tree division. Such injuries are often associated with right hepatic arterial injuries which may lead to torrential bleeding followed by conversion or may simply be an unrecognized occlusion of the artery.¹³

A second misidentification injury involves the aberrant right hepatic duct, present in 2% of patients. The segment of the aberrant right hepatic duct lying between its junction with the cystic duct and the point at which it joins the common hepatic is misidentified as the cystic duct. Hence, the surgeon unknowingly clips and cuts out this segment. For removal of the gallbladder, the aberrant duct gets cut again, but at a higher level.

The direction of traction of the gallbladder has been known to contribute to the appearance that the common bile duct is the cystic duct and this can lead to the misidentification injury. When the pouch of Hartmann is pulled superiorly instead of laterally, the cystic and common bile ducts are aligned and appear as a single structure.¹⁴ This deception is more common when the following factors are present—a short cystic duct, a large stone in the pouch of Hartmann and severe, acute and chronic inflammation. Mirizzi's syndrome, in which the gallbladder communicates directly with the common bile duct following recurrent inflammation, is a common cause for error. Misidentification may lead to injury of the bile duct even without division or clipping, because extensive dissection can lead to devascularization of the bile duct which present later as a stricture.

Technical Errors

Failure to occlude the cystic duct securely: Closure of cystic duct is usually done by clips, which remains unreliable if not applied correctly, as opposed to ligatures in open surgery. Clips may 'scissor' during application, resulting in faulty closure or be loosened by subsequent dissection.

Too deep dissection on the liver bed: Injury to ducts in the liver bed is due to dissection in too deep a plane while

removing the gallbladder. It often occurs when the dissection is difficult especially or when the gallbladder is intrahepatic.

Thermal injuries: Cautery induced injuries are also more common in the presence of severe inflammation. This is due to the use of excessively high cautery settings to control hemorrhage.

Tenting injuries: In a tenting injury, the junction of the common bile duct and hepatic bile ducts is occluded when a clip is placed at the bottom end of the cystic duct while forcefully pulling up on the gallbladder.

Prevention of Bile Duct Injuries

Bile duct injury should be regarded as preventable, but in a study of surgeons' anonymous response after bile duct injury during cholecystectomy published in the *American Journal of Surgery* in 2003, over 70% of surgeons regarded it as unavoidable.¹⁵ Following early experiences with such injuries in early 90's, Hunter and Troidl proposed several techniques to prevent injury: A 30° telescope, avoidance of diathermy close to the common hepatic duct, dissection close to the gallbladder—cystic duct junction, avoidance of unnecessary dissection close to the cystic duct—common hepatic duct junction, and conversion to an open approach when uncertain.^{16,17} However, to apply these techniques, correct interpretation of the anatomy is required.

Preventing Misidentification Errors

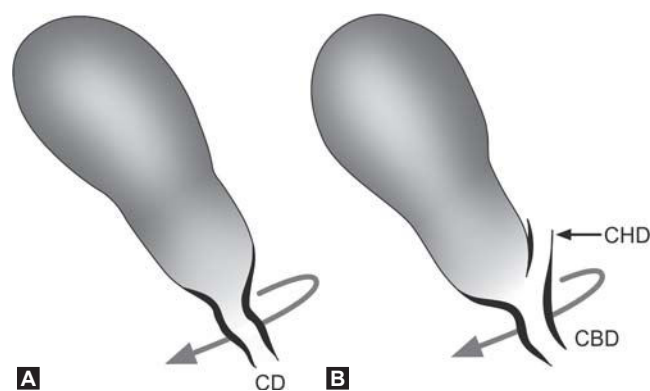
Misidentification is due to failure to achieve conclusive identification of the cystic structures. The cystic duct and artery are the only structures that require division during cholecystectomy, hence the objective of dissection primarily is to identify these structures conclusively. There are several methods of identification of the cystic duct. In the open method, display of the confluence of the cystic duct with the common hepatic duct to form the common bile duct was used which is considered not safe in the laparoscopic method. In the laparoscopic form of surgery, techniques used are intraoperative cholangiography, the infundibular technique and the critical view technique.

The infundibular technique is a method initially used for ductal identification based on three-dimensional demonstration of the funnel-like shape of the lower end of the gallbladder and adjacent cystic duct. To obtain this view, cystic duct is followed onto the gallbladder or the lower end of the gallbladder is traced down to the cystic duct. When dissection is completed, the funnel-shaped union of cystic duct with gallbladder can be seen in three dimensions. The fallacy of this technique is obtaining a false 'infundibular views' when the CBD is followed up to an

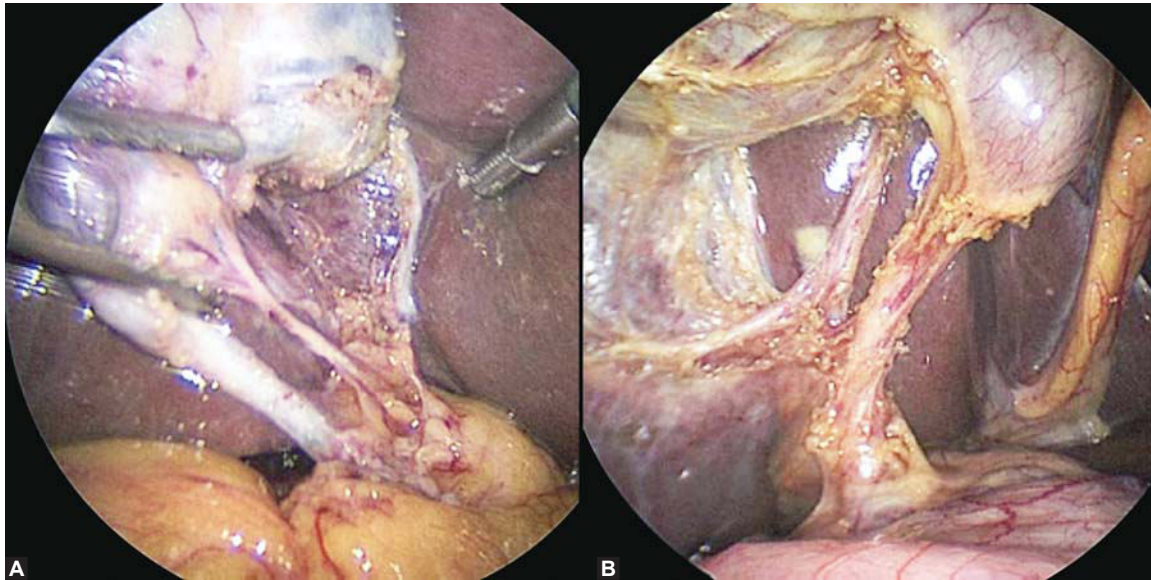
inflammatory mass within which the cystic duct is hidden (Figs 2A and B). This visual deception occurs especially in presence of severe acute or chronic inflammation, a large stone in the pouch of Hartmann, adhesive bands between the gallbladder and the common hepatic duct and intrahepatic gallbladder. Chronic inflammation tends to cause retraction of structures in the porta hepatis, bringing the gallbladder against the CHD so that it appears as a part of the gallbladder wall. If this view is relied upon for ductal identification it will, in these cases, result in division of the CBD.¹⁸

The critical view of safety technique, advocated by Strasberg involves tentative identification of these cystic structures by dissection in the triangle of Calot (Figs 3A and B), followed by dissection of the gallbladder off the liver bed. In this technique, the triangle of Calot is cleared of fat and fibrous tissue and after detachment of the gallbladder; only two structures are connected to the lower end of the gallbladder—the cystic duct and artery. It is not necessary or recommended that the CBD be visualized.² Failure to achieve this critical view is an absolute indication for conversion or possibly cholangiography to define ductal anatomy.

Following its introduction, this critical view method has been accepted by many surgeons for its superior results with regards to minimizing BDIs. Averginos et al in 2009 published the result of 1046 cholecystectomies without BDI using the critical view method.²⁰ Only five patients had transient biliary leaks in the postoperative period which subsided within 2 to 14 days. Similarly, Yegiyants and Collins analyzed the role of critical view of safety in 3,000 patients undergoing elective cholecystectomy and reported one bile duct injury, which occurred during dissection of Calot's triangle, prior to achieving the critical view.^{19,21} Sanjay et al in 2010 studied its safety in 447 cholecystectomies done for acute biliary pathologies and reported no BDIs. Critical view was obtained in 388 (87%) patients and



Figs 2A and B: (A) The usual anatomy when the infundibular technique is used, (B) anatomical situation in some cases of classical injuries²¹



Figs 3A and B: (A) Critical view of safety (CVS) is seen from in front of the gallbladder as usually shown, (B) CVS is seen with the gallbladder reflected to the left, so that a posterior view of the triangle of Calot is shown²²

in the remaining where it was not obtained, conversion to open surgery was done.²²

Another method of conclusive identification of cystic structures is by routine intraoperative cholangiogram. Several prospective studies have tried to evaluate the usefulness of IOC in preventing CBD injury. A meta-analysis of 40 case series detailing 327,523 LCs and 405 major injuries was performed in 2002.²³ Rate of injury was halved in the routine IOC group (0.21%) as compared with the selective group (0.43%). In addition, in the selective group, only 21.7% of CBD injuries were detected intraoperatively. Fletcher et al found that routine IOC reduced the incidence of injury.²⁴ The study method adjusted for confounding variables, such as age, sex, hospital type and severity of disease. One argument against cholangiography is, if the CBD is misidentified while an IOC is being performed, the ductotomy created for placement of the IOC catheter is itself a CBD injury. However, other studies suggest that the severity, but not the incidence of biliary injury is reduced by routine IOC. Operative cholangiography is best at detecting misidentification of the common bile duct as the cystic duct and will prevent excisional injuries of bile ducts, if the cholangiogram is correctly interpreted. In an analysis of 252 bile duct injuries during cholecystectomy, Way et al reported that 43 IOCs demonstrated a bile duct injury, but only nine were correctly interpreted at the time of operation.²⁵

Recently, other techniques proposed to correctly identify biliary anatomy include the use of dyes. Ishizawa et al reported using fluorescent cholangiography technique using the intravenous injection of indocyanine green.²⁶ The biliary

structure was delineated in all 52 patients studied using the fluorescent imaging system. However, the cost involved is a deterrent for widespread use. Similarly, Sari et al proposed injecting methylene blue in the gallbladder after aspirating the bile with a Varess needle before starting dissection.²⁷

To overcome the problem of anatomical orientation, before starting dissection, identification of fixed anatomical landmarks is helpful. Hugh recommends identifying Rouviere's sulcus as a fixed extrabiliary point ventral to the right portal pedicle.²⁸ Dissection ventral to this allows a triangle of safe dissection when the gallbladder has been reflected cephalad. Extending this dissection as far as possible up the gallbladder fossa both posteriorly and anteriorly allows the hepatobiliary triangle to open out. This ensures no unexpected anatomy and confirms the correct anatomical position before any significant structure is divided.

In cases of difficulties due to severe adhesion of the gallbladder to surrounding and severe fibrosis, some have advocated using laparoscopic subtotal cholecystectomy as an alternative to conversion as equal difficulty in dissection would be required in the open surgery as well. They claim that conversion does not guarantee the avoidance of inadvertent biliary or vascular injury.²⁹ Tian et al in 2009, reported performing laparoscopic subtotal cholecystectomy in 48 difficult cases out of 1558 laparoscopic cholecystectomies without any serious bile duct injuries.³⁰

Human Factors and Bile Duct Injury

Although thorough instruction in the principles of safe surgical technique for cholecystectomy is essential, it may be equally important to develop new training strategies that

use knowledge of psychologic factors in the production of error. This is the human factors approach described by Reason in 'high-reliability organizations', such as air-traffic control and the nuclear power industry.³¹ In such environments, highly trained professionals carry out complex technical tasks and are sometimes required to make rapid decisions in conditions of uncertainty with potentially disastrous consequences of mistakes. Some error is inevitable when human beings interact with complex technical environments, as in the operating room. A specific type of error, recognized as the cause of some aircraft crashes, seems to operate in many cases of bile duct injury: The false hypothesis or deadly mind-set error. A mistaken perception, that a particular duct is the cystic duct, provides the setting for this type of error in cholecystectomy. The surgeon may develop a functional fixity and reject evidence of a mistake. The unwillingness of juniors to question the actions of seniors has been identified as a significant contribution to errors in the operating room. The characteristics of a surgeon at low risk for error is often identified as being a person who expects unpleasant surprises; accepts input from others; is ready to modify hypotheses; and recognizes the effects of self-fatigue, time pressures, and personal worries on surgical performance. Hunter suggested that a team approach may be beneficial, stating that the cystic duct should not be clipped until all members of the operating team are contented that the dissection is complete.¹⁶

CONCLUSION

Bile duct injuries have cast a shadow of apprehension on an otherwise wonderful procedure of laparoscopic cholecystectomy. Millions have benefited from this advance against gallbladder disease. Hence, to preserve these benefits, the operating surgeon has to be aware of the factors responsible for these injuries and take appropriate measures to prevent them. This requires strict adherence to the principles of meticulous dissection so that only positively identified structures are divided. Routine use of intraoperative cholangiograms and converting to open procedure in the event of failure to progress or uncertain anatomy would go a long way in significantly reducing this mishap.

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