Bile duct injuries: Mechanism and prevention

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ABSTRACT

Operative bile duct injury is one of the serious complications of hepato-biliary surgery. It is feared because of the substantial morbidity, occasional mortality, additional expenditure and frequent litigation that accompany it. With the introduction of laparoscopic cholecystectomy (LC) there was an increase in the incidence of such injuries and their pattern also changed to more complicated varieties.

The popularity of LC and various percutaneous endoscopic procedures for bile duct pathologies have made the younger generation of surgeons less familiar with open cholecystectomy and open operative approaches to bile duct injuries. A review of the literature pertaining to the mechanism of bile duct injuries, during both open and LC, and the techniques of their prevention, was carried out by Medline search; with the aim of helping surgeons in optimising their efforts of preventing these tragic accidents.

Key Words: Cholecystectomy, bile duct, injuries

INTRODUCTION

Carl Langenbuch performed the first open cholecystectomy in 1882.[1] It was not until 1905 that Mayo reported the first two cases of bile duct strictures following cholecystectomy.[2] As surgeons gained more experience and the open biliary operations became standardized the incidence of bile duct injuries came down to around 0.125%.[3] Open cholecystectomy remained the gold standard for treatment of cholelithiasis till the late 1980s when laparoscopic cholecystectomy (LC) was first introduced.[4] It gained widespread acceptance and became the new gold standard for the management of gall stone diseases. During the surgical learning curve of this new technique there was an initial spurt in the reports of bile duct injuries[5] resulting mainly from the surgeon’s inexperience and misinterpretation of anatomy. The mechanism and pattern of injuries differed in some ways from the traditional ones.[5] Though the reported figures of operative bile duct injuries are much lower than the actual incidence a recent audit of 1522 LC performed in Thailand revealed bile duct injury rate of 0.59%,[6] i.e. almost four times the incidence reported for open cholecystectomy. Though the initial spike has settled down as surgeons became cautious of the reported complications[7] reports of major bile duct injuries, even in the hands of senior surgeons, continue to surface suggesting that bile duct injuries following cholecystectomy will always remain a significant problem.

MECHANISM OF BILE DUCT INJURIES

Asbun et al.[8] have enumerated the following risk factors of bile duct injury after having reviewed a series of 21 patients referred to Lahey Clinic with iatrogenic common bile duct injuries

Anatomical anomalies

Common anomalies responsible for bile duct injuries include those of the cystic duct (CD) and its insertion into the common hepatic duct (CHD) e.g. long parallel course with the CHD or a spiralling CD opening on the medial aspect of the CHD. Anomalies of the right hepatic duct (RHD) e.g. low insertion on to the CHD, right anterior and posterior sectoral hepatic ducts, anomalies of the right hepatic artery and aberrant vessels coursing along the common bile duct (CBD) are other
important examples.

**Local pathology**

Acute inflammation around the Calot’s triangle makes the tissue friable and difficult to grasp. Dissection in such conditions leads to excessive oozing of blood. These along with the distorted anatomy increase the risk of bile duct injuries during LC. On the other hand, extensive fibrosis around the Calot’s triangle in cases with chronically inflamed and fibrosed gall bladder may similarly preclude safe dissection. In such cases partial cholecystectomy is justified as otherwise there remains a high risk of bile duct injuries.

**Technical aspects**

Bile duct injuries occur even in the hands of experienced and competent surgeons, but obviously, inexperience increases the risk manifold. A casual attitude towards a “simple gall bladder” may result in a catastrophe. A Swedish study has shown that a surgeon is more likely to injure the bile duct between his 25th and 100th open cholecystectomy. Inadequate exposure in open cholecystectomy or improper placement of trocars, improper assistance including retraction, hasty and injudicious application of clamps or clips to arrest haemorrhage, are important technical factors often resulting in bile duct injuries. Overzealous use of electrocautery near the Calot’s triangle and extensive dissection around the CBD damage its axial blood flow leading to ischemic damage to the duct and late stricture formation.

Excessive traction leading to the tenting of the CBD is another factor predisposing to clipping and ligation of the bile duct, especially in open cholecystectomy. An unnecessary attempt to demonstrate the junction of the cystic duct and the CBD can be potentially dangerous. Obesity and excessive fat in the porta hepatic poses technical difficulties and predisposes to bile duct injuries.

Davidoff et al had described the mechanism of “classic” laparoscopic injury in the presence of “normal” anatomy of the biliary tree, a pattern rarely seen in open cholecystectomy, occurring when the gall bladder is retracted superiorly and laterally causing alignment of the CD and CBD with the CHD running at right angles to them. Here the CBD is mistaken for the CD and divided. Dissection proceeds upwards along the medial aspect of the CBD and CHD until damage to the right hepatic artery results; finally the CHD is clipped and excised revealing at the end the CD and the cystic artery. Hunter described a variant of this event where a faulty anterior and medial traction on the Hartman’s pouch fails to open up the Calot’s triangle causing the CD and the CHD to become aligned in the same plane (Figure 1a) and the CBD is mistaken as the CD and clipped. Subsequent clip is placed on the CD and the CD is divided. This results in distal obstruction of the CBD and a fistula through the open CD remnant.

Dissection into the liver parenchyma while separating the gall bladder from the liver bed causes bleeding which obscures the anatomy, and blind attempts at hemostasis with clamps, clips or electrocautery increases the likelihood of bile duct injuries. Moreover, straying into the liver bed can damage the right sectoral hepatic duct, an anomalous right hepatic artery or a major right portal pedicle.

Operative exploration and/or choledochoduodenoscopy on a small calibre CBD is potentially dangerous as it is likely to result in stricture formation and cholangitis. Endoscopic procedures after cholecystectomy are a better choice in such patients having small calibre CBD with stones, papillary stenosis or distal stricture.

**Human factors and cognitive psychology**

Lawrence et al analysed the data of 252 laparoscopic bile duct injuries, including operative radiographs, clinical records and videotapes of original operation from the perspectives of visual perception, judgment and human errors to show that errors leading to laparoscopic bile duct injuries stem principally from visual perceptual illusion, not from errors of skill, knowledge and judgement. The misperception was so compelling that in most cases the surgeon did not recognize a problem. Even when irregularities were identified, corrective feedback did not occur, which is characteristic of human thinking under firmly held assumptions.

**TYPES OF INJURIES**

**Biliary leak**

The leak may be a minor one arising from small, accessory bile duct and clinically insignificant; it may be treated by percutaneous drainage. Balija et al found that lesions of the accessory bile duct are the...
commonest cause of postoperative complication. On the other hand a major leak arising from injury to a main duct or retained stone in CBD results in biliary fistula, peritonitis or biloma.

**Cystic duct injuries**

It is a common cause of biliary fistula following LC. Mostly results from improper application of clips and their slippage. Use of diathermy to divide the CD may cause the charring of tissue and failure of the clip to hold. ERCP helps in diagnosis, removes doubts regarding possible major ductal injuries. The condition resolves spontaneously provided there is no distal obstruction; the process may be hastened by the placement of a stent endoscopically.

**Extrahepatic bile duct injuries**

Only 29% of the injuries are recognized per-operatively. The injury varies from partial tear of the bile duct to laceration, transection and even excision of a portion of the duct. They are seen irrespective of the type of cholecystectomy and result in biliary stricture which is undoubtedly the most serious complication following cholecystectomy. The severity of the complication depends on the type of injury, the delay in presentation and on whether the patient requires a revision of an initial attempt to repair. Injuries identified and repaired at the time of the first operation afford good results.

In bile duct excision a portion of the bile duct is lost and simple repair, as may be done in transection and laceration is not possible. Chances of late stricture are more in bile duct transection in comparison to laceration as the axial vascular supply of the CBD is damaged in a transected CBD. Biliary reconstruction in the presence of peritonitis, combined vascular and bile duct injuries, and injuries at or above the level of the biliary bifurcation were significant independent predictors of poor outcome.

**Intrahepatic bile duct injuries**

These include injuries at or above the bifurcation of the CHD and are more often seen with LC than with open cholecystectomy. They may result following the “classic” injury described above or during the dissection of the gall bladder, with a fibrosed Calot’s triangle, from its bed.

**Strictures**

Strictures may develop early (within days or weeks) or late (take years to develop) and vary in diameter and length. Early strictures may develop due to peroperative complications like clamping, ligation or clipping of the duct or thermal injury. Local infection may also result in both early and delayed stricture formation. Thermal injury and occult malignancy are important causes of delayed stricture formation. Bismuth classified biliary strictures into five types (Figure 2).

Type 1: Stricture >2 cm from the confluence of the hepatic ducts.
Type 2: Stricture <2 cm from the confluence with remnant of the CHD.
Type 3: Stricture flush with the confluence with the confluence intact.
Type 4: Stricture involves the confluence.
Type 5: Stricture involving an aberrant right sectoral hepatic duct, with or without a concomitant CHD stricture.

A review of 74 patients at the Vanderbilt University Medical Center, Nashville, referred with bile duct injuries sustained during LC suggested that they are frequently severe and related to cautery and high clip ligation and the level of injury was almost evenly divided between Bismuth Type 3, 4 and 5 versus Bismuth Type 1 and 2.

Strasberg et al made Bismuth’s classification much more comprehensive by including various other types of laparoscopic extrahepatic bile duct injuries. The injuries were classified from Type A to Type E. The latter, representing biliary strictures, has been further subdivided as per Bismuth’s classification into E1 to E5. Type A injuries are bile leak from injured minor ducts like cystic duct and duct of Lushka. Type B denotes occlusion of a part of the biliary tree, almost invariably the aberrant right sectoral hepatic duct. Type C represents transaction without ligation of the right sectoral hepatic duct and Type D a lateral injury to an extrahepatic bile duct, potentially requiring a major reconstruction (Figure 3).

**PREVENTION**

A thorough knowledge of the anatomy of the region including the possible anomalies is important in preventing iatrogenic bile duct injuries. Both open and LC are based on similar operative principals. Proper
exposure and visualization, careful dissection, adequate hemostasis, careful placement of ligatures and clips and division of structures after proper identification are the essence of safe cholecystectomy.

Laparoscopic cholecystectomy
Lawrence et al.\textsuperscript{[12]} stressed on focused training to heighten vigilance against visual perception illusion and errors of judgement as they showed that there are only a few points within LC where complication-causing errors occur like mistaking the CBD to be the CD or dissection too close to the CHD. The early prediction that the rate of bile duct injury during LC would decline substantially with increased experience has not been fulfilled. Since the injuries occurring at LC are frequently more severe and extend to a higher level than in open cholecystectomy (Strasberg E3 to E5 injuries occur in 31% of LC against 12% of open cholecystectomy) prevention should always be the aim.\textsuperscript{[20]} Asbun et al.\textsuperscript{[8]} have stressed on the following steps for preventing iatrogenic bile duct injuries:

- Maximum cephalic fundal traction for better visualization of the Calot’s triangle.
- Lateral and inferior traction on the Hartman’s pouch opens up the angle between the CD and the CHD and avoids their alignment (Figure 1b).
- Calot’s triangle must be freed of fatty and areolar tissue.
- Dissection to be started near the neck of the gall bladder (cystic lymph node is an important landmark) and then proceed from the lateral to the medial direction, keeping close to the gall bladder.
- Freeing the posterolateral attachments of the gall bladder to the liver creates a good window and the junction of the neck of the gall bladder and the CD is defined all round. Visual identification of the CBD is not essential or recommended.
- A 30° telescope is preferable as it can be turned to achieve an en face view of the Calot’s triangle. Withdrawing the telescope intermittently gives the surgeon an overall perspective and spatial orientation.
- Clips are to be placed close to the gall bladder after proper visualization of both their limbs. A short or wide CD should preferably be tied.
- Excessive and unnecessary dissection or use of electrocautery near the CBD to be avoided. Cautery to be used at very low power setting in Calot’s triangle.\textsuperscript{[21]}
- Electrocautery on tissues close to metal clips concentrates thermal energy and desiccates the tissue making the clips less secure predisposing to bleeding and biliary fistula and hence should always be avoided.
- Any bleeding should be controlled only after accurate identification of its source and the neighbouring structures.
- Dissection should be close to the gall bladder while it is separated from the liver bed.
- Always better to seek the opinion of senior colleagues of the same institution if one feels “lost”; if doubt persists convert to open cholecystectomy—it only shows good judgement.

Open cholecystectomy
- Adequate incision, good retraction and able assistance help in proper exposure and visualization and are prerequisites for safe cholecystectomy.
- Proper identification of the structures of the Calot’s triangle before any structure is ligated or divided. It is important to remain close to the gall bladder during dissection to avoid injury to the RHD or one of its anomalies.
- If the anatomy is not clear a cholecystostomy or partial cholecystectomy is preferable.
- In cirrhosis, excessive bleeding during separation of the gall bladder may be reduced by leaving the posterior wall of the gall bladder denuded of its mucosa, attached to the liver bed.
- When haemorrhage obscures the anatomy one should refrain from using clamps blindly. Instead, Pringle manoeuvre helps in better visualization and accurate placement of clips and clamps.
- Both antegrade and retrograde cholecystectomy may be associated with CBD injury and thus neither should give a false sense of security to the operating surgeon.

CONCLUSION
Bile duct injuries are rare complications of both open and LC. They can devastate an individual by turning him into a “biliary cripple” and most ultimately die of hepatic failure. They often result from errors of human judgement and are thus preventable. A marriage of the experiences gained from open cholecystectomy and the advantages of LC in terms of visualization and magnification will help in reducing the incidence of
such catastrophes.

REFERENCES


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