

Avoidance of biliary injury during laparoscopic cholecystectomy

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Abstract Biliary injury during laparoscopic cholecystectomy is still a serious problem. Injury occurs as a result of technical errors or misidentification of ducts. Inexperience, inflammation, and aberrant anatomy are key risk factors. The most serious technical problem is cautery-induced injury. This problem may be avoided by use of cautery under very low power settings in the triangle of Calot. Misidentification injuries occur when the surgeon mistakes the common bile duct or an aberrant right hepatic duct for the cystic duct. This error usually occurs when the surgeon uses the “infundibular” technique to identify the cystic duct. This technique, which depends on seeing the cystic duct flare as it becomes the infundibulum, is especially prone to be misleading in the face of acute inflammation. This technique is unreliable and should not be used alone for anatomic identification of the ducts. It is preferable to use the critical view technique or to perform a cholangiogram.

Key words Laparoscopic cholecystectomy · Biliary injury · Critical view

Introduction

Biliary injury during laparoscopic cholecystectomy continues to be an important clinical problem, resulting in serious morbidity to patients. Injury rates may be decreasing, but have not attained the levels that were once present in the era of open cholecystectomy.^{1–3} We have classified the causes of biliary injuries into two types of surgical problems — problems of technique and problems of misidentification.⁴ This paper will review the causes of biliary injury and their avoidance. The injury

classification to be used in this paper was introduced in 1995 (Fig. 1).⁴

Risk factors for biliary injury

Training and experience

The high rate of biliary injury in early reports was due in part to inexperience in the procedure. This was called the “learning curve” effect.^{5,6} Although inexperience did initially contribute to the high incidence of injury, other factors are responsible for current rates of injury.

Local risk factors

Biliary injuries are more likely to occur during difficult laparoscopic cholecystectomies.^{3,7,8} The incidence of injury when laparoscopic cholecystectomy is performed for acute cholecystitis (0.51%) was reported to be three times higher than that for elective laparoscopic cholecystectomy and twice as high as that for open cholecystectomy for acute cholecystitis.³ Other factors are chronic inflammation with dense scarring,⁹ operative bleeding obscuring the field, or fat in the portal area.^{10–13} The role of obesity is difficult to evaluate, because it is so often present in patients with cholelithiasis.

Aberrant anatomy

This is a well-described danger in biliary surgery. The aberrant right hepatic duct anomaly is the most common problem. There are several reports of injury to aberrant right hepatic ducts during laparoscopic cholecystectomy.^{14–16} These injuries are probably underreported, because occlusion of an aberrant duct may be asymptomatic.¹⁷ Aberrant right hepatic ducts appear to be particularly prone to injury during laparoscopic cholecystectomy.⁴

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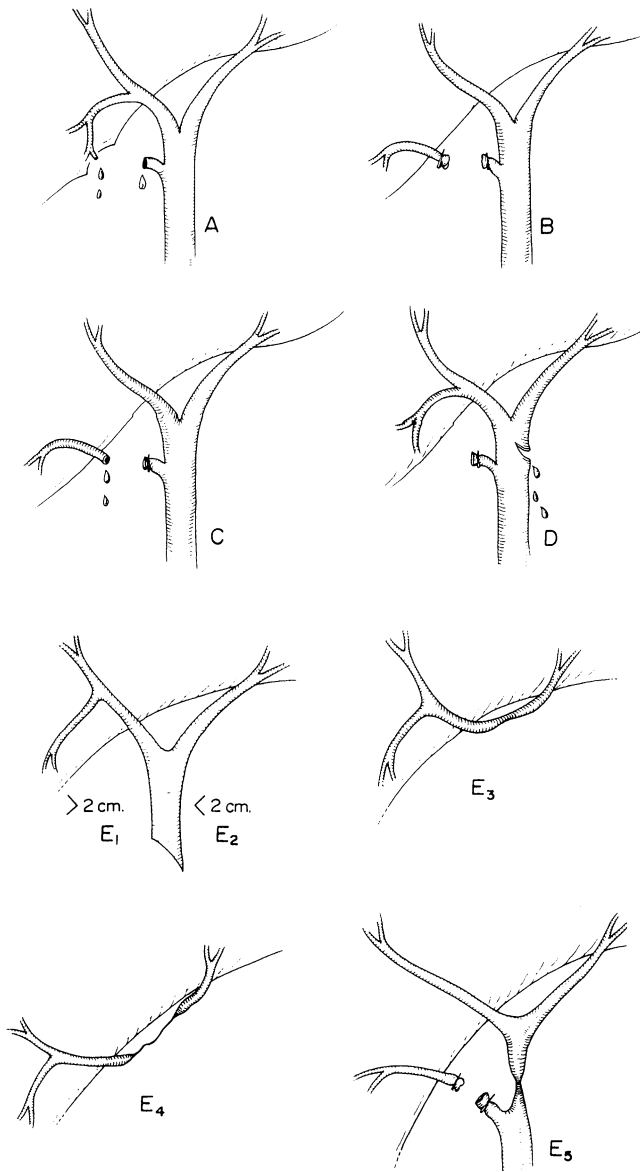


Fig. 1. Classification of laparoscopic injuries to the biliary tract. Injuries of types A to E are illustrated. Type E injuries are subdivided according to the Bismuth classification. Type A injuries are cystic duct leaks or leaks from small ducts in the liver bed. Type B and C injuries almost always involve aberrant right hepatic ducts. Type D injuries are lateral injuries to major bile ducts. The notations $>2\text{cm}$ and $<2\text{cm}$ in type E1 and type E2 indicate the length of common hepatic duct remaining. From reference 4, by permission of the *Journal of the American College of Surgeons*

Equipment

Maintenance of laparoscopic equipment must be a high priority. Focal loss of insulation on instruments used for cauterization may lead to thermal injuries to bile ducts or surrounding structures.¹⁸

The direct causes of laparoscopic biliary injury and their avoidance

General

Only surgeons trained and proctored in laparoscopic cholecystectomy should perform the operation. Difficult procedures, such as laparoscopic cholecystectomy for acute cholecystitis, should not be attempted until experience is gained.³ The procedure is also more difficult when the patients are males, elderly, or when there have been repeated attacks of pain¹⁹ or previous attacks of acute cholecystitis.¹⁹ All surgeons should be aware of these predictive factors and take appropriate steps to ensure adequate assistance in the operating room. Laparoscopic cholecystectomy during an attack of acute cholecystitis should be classified as an advanced laparoscopic technique when credentialing surgeons.

Specific direct causes

Biliary injury occurs either due to technical problems, especially the misuse of cautery, or due to anatomical misidentification of the cystic duct.

Technical problems

Failure to occlude the cystic duct securely. The cystic duct is usually occluded with clips. These are less reliable than ligatures or suture ligatures, which were the standard methods of occluding the cystic duct during open cholecystectomy. The main problem is the inappropriate use of clips instead of another occlusion device on a thick rigid cystic duct. Retained stones in the bile duct may contribute to clip failure by raising biliary tract pressures.²⁰ Clips may "scissor" during application, resulting in faulty closure, or be loosened by subsequent dissection.

Avoidance. Clips should be applied so that their tips are seen projecting beyond the duct, free of any extraneous material. Clips should not be touched in the subsequent dissection. When the cystic duct is thick, preformed ligature loops should be used in place of clips. Two loops should be applied on the side of the cystic duct to be retained. Applying extra clips is not the answer and may, in fact, lead to tenting injury.

Too deep a plane of dissection on the liver bed. Injury to ducts in the liver bed is due to dissection in too deep a plane when elevating the gallbladder. It often occurs when the dissection is difficult; for instance, when acute or severe chronic inflammation is present or when the gallbladder is intrahepatic.

Avoidance. This requires that the dissection is in the correct plane. Use of the spatula dissector combined with irrigation to keep the field clear of blood is often helpful. The cautery scissors are also useful, but there is

no substitute for gentle meticulous technique and experience in this dissection.

Thermal injuries. Cautery-induced injuries are also more likely to occur in the presence of severe inflammation, because this condition may lead to the use of excessively high cautery settings to control hemorrhage. Misuse of cautery may cause very serious bile duct injuries, with loss of ductal tissue due to thermal necrosis.

Avoidance. Cautery should be used only with great care in the triangle of Calot. This requires low cautery settings, coagulation of small pieces of tissue at one time, and being sure that the coagulating surface is free of any adjacent tissue. Low cautery settings are essential, characteristically 25 W or less. Higher settings may lead to arcing of current to ducts. The cystic duct should not be divided by diathermy, because this may lead to thermal necrosis of the cystic duct stump or adjacent bile duct.²¹ Hemorrhage should not be arrested by blind application of cautery clamps, or clips. Brisk bleeding requires conversion.

Tenting injuries. This was a well-described problem in the open-cholecystectomy era. 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. There are few reports of this injury during laparoscopic cholecystectomy. In fact it may be less common during laparoscopic cholecystectomy, due to excellent visualization of properly identified cystic ducts.

Avoidance. The injury is avoided by not pulling up on the gallbladder forcefully when applying clips and, most importantly, by direct observation that a piece of cystic duct remains below the clip applied closest to the common bile duct end of the cystic duct.

Problems of misidentification

The most serious injuries are caused by misidentification. There are two main types of misidentification. In the first, the common duct is mistaken to be the cystic duct, and is occluded and divided. The bile ducts must be divided again later in the dissection in order complete the excision of the gallbladder. The type of injury produced depends on the level of this second division, and may be E1–E4 in type. A “second cystic duct” or “accessory duct”, which is actually the common bile duct or even more proximal ducts may be remarked on in the operative notes of these procedures. Just as often the second transection of the biliary tree is not noted. High transections may be caused by pulling on the gallbladder, i.e., by actually distracting hepatic ducts downward during transection of the biliary tree. The hepatic ducts may be clipped or divided, producing either ob-

struction or bile leak. The injury is often associated with damage to the right hepatic artery. This may cause brisk bleeding that leads to conversion and diagnosis of biliary injury, or it may simply result in unrecognized occlusion of the artery. Either may aggravate the biliary injury due to ischemia of the remnant bile duct.⁶ At the time of reconstruction there may be evidence of dissection on the left side of the common duct, even to the point of exposure of the portal vein.

The second type of misidentification leads to injury to an aberrant right hepatic duct. The segment of the aberrant right hepatic duct, between the entry of the cystic duct and the junction with the common hepatic duct, is thought to be the cystic duct. The misidentified segment is clipped and usually cut. To remove the gallbladder the aberrant duct must be cut again at a higher level.

It is well known that the direction of traction of the gallbladder may contribute to the appearance that the common bile duct is the cystic duct and that this can lead to the misidentification injury. When the pouch of Hartmann is pulled superiorly rather than laterally, the cystic and common bile ducts are aligned and appear to be a single structure. Incorrect traction has undoubtedly contributed to some injuries — especially early in the learning curve. However, we have recently shown that it is the reliance on the appearance of the lower end of the gallbladder for identification of the cystic duct, i.e., the so called “infundibular technique”, that is responsible for many misidentification injuries. In this infundibular method the surgeon is instructed to follow the putative cystic duct up to the gallbladder, at which point it can be seen flaring out to become the infundibulum. It is this widening or flaring that was thought to give a safe identification of the infundibulo-cystic junction and, therefore, safe identification of the cystic duct. However, we have reported that when the common bile duct (instead of the cystic duct) is isolated and followed upward it may “flare” at the point where the cystic and common hepatic ducts connect to it.²² In other words, the appearance may deceptively resemble the infundibulo-cystic junction.²² This deception is most likely to occur when one or more factors are present,²² i.e., a short cystic duct, and a large stone in the pouch of Hartmann and severe acute and chronic inflammation. All of these factors make retraction and display of the real cystic duct difficult. The end-stage of this pathology is Mirizzi’s syndrome, which effaces the cystic duct so that the gallbladder communicates directly with the common bile duct. Also, misidentification is more common when adhesive bands tether the gallbladder to the common bile duct. Misidentification may lead to injury of the bile duct without division or clipping, because extensive dissection may cause devascularization, particularly if ductal arteries, thought to be the cystic artery, are divided. This type of injury may present later as a stricture.

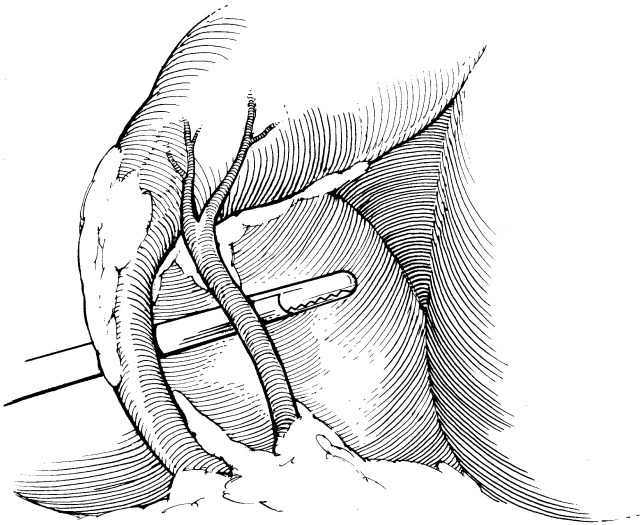


Fig. 2. The “critical view of safety”. The triangle of Calot is dissected free of all tissue except for the cystic duct and artery and the base of the liver bed is exposed. When this view is achieved, the two structures entering the gallbladder can only be the cystic duct and artery. It is not necessary to see the common bile duct. From reference 4, by permission of the *Journal of the American College of Surgeons*

Avoidance. 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. The objective of dissection is to identify these structures *conclusively*.⁴ Only these structures need to be identified. “Conclusive identification” is the key. In 1995, we introduced a technique for conclusive identification of the cystic structures at laparoscopic cholecystectomy, based on a “critical view of safety” (Fig. 2).⁴ In this technique, the triangle of Calot is cleared of fat and fibrous tissue. Only two structures are connected to the lower end of the gallbladder once this is done, and the lowest part of the gallbladder attachment to the liver bed has been exposed. The latter is an important step, equivalent in the open technique to taking the gallbladder off the liver bed. It is not necessary to expose the common bile duct. Once the critical view is attained, cystic structures may be occluded, as they have been conclusively identified. Failure to achieve the critical view is an indication for conversion or, possibly, cholangiography to define ductal anatomy. It is the author’s opinion that there is considerable danger in relying simply on the appearance of the “cystic duct” — gallbladder junction, as this may be deceiving, especially in the presence of severe inflammation.

Another method of conclusive identification is by routine intraoperative cholangiogram (RIOC). A recent report from Australia found that RIOC reduced

the incidence of injury.²³ The study method adjusted for confounding variables such as age, sex, hospital type, and severity of disease. Other studies suggest that the severity, but not the incidence of biliary injury is reduced by RIOC.^{24–26} 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. However, operative cholangiograms are sometimes misinterpreted in the presence of injury.^{27,28} The most common problem is the failure to recognize that visualization of only the common bile duct, (i.e., without visualization of the common hepatic duct and intrahepatic ducts) indicates that the common bile duct rather than the cystic duct has been cannulated. A lack of appreciation of this finding may lead to an excisional injury. Furthermore, the incision in the common bile duct made in order to perform RIOC may not be innocuous. It will, at the least, require conversion and repair over a T-tube and, at worst, require biliary reconstruction. Furthermore, RIOC is very poor at detecting aberrant right ducts, which unite with the cystic duct before joining the common duct. The aberrant duct appears to be the cystic duct visually and on cholangiograms. The reason for the cholangiographic deception is that when dye is injected into the aberrant duct it flows into the common bile duct, common hepatic duct, and intrahepatic ducts, including some right-sided hepatic ducts. Unless the surgeon or radiologist notices that there is a paucity of right posterior sectional ducts, the cholangiogram will be misinterpreted as “normal” and the aberrant right posterior duct will be clipped and divided. As a result of these considerations, many argue that meticulous dissection of the triangle of Calot, as was done during the open era, is the correct means of anatomical identification. The author believes that conclusive identification of the anatomy by the “critical view” technique is the method of choice for identification of biliary anatomy during laparoscopic cholecystectomy — but that if this method is not used, RIOC should be employed.

Summary

Biliary injury is caused by technical problems and conceptual errors that lead to misidentification. Technical errors may usually be avoided by meticulous dissection techniques, careful use of cautery, the use of ligatures rather than clips on thick-walled ducts, and experience. To avoid misidentification, one should either dissect to the critical view or use RIOC. The infundibular technique should not be used as the exclusive method of cystic duct identification, because it is unreliable.

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