

Bile duct injury in the era of laparoscopic cholecystectomy

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Background: Laparoscopic cholecystectomy is the standard of care for symptomatic cholelithiasis, but it is associated with a higher incidence of bile duct injury than the open approach.

Methods: A review was performed of the English language literature on the management of bile duct injury listed on Medline databases.

Results and conclusion: There is 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. Early detection and repair is associated with an improved outcome, and the minimum standard of care after the recognition of a bile duct injury is immediate referral to a surgeon experienced in bile duct injury repair. Surgery provides the mainstay of treatment, with proximal hepaticojejunostomy Roux en Y being the operation of choice; a selective role for endoscopic or radiological treatment exists. The outcome after bile duct injury remains poor, especially in relation to the initial expectation of the cholecystectomy. Patients are often committed to a decade of follow-up.

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Introduction

Bile duct injury following cholecystectomy is an iatrogenic catastrophe associated with significant perioperative morbidity^{1,2} and mortality^{1,2}, reduced long-term survival³ and quality of life^{4,5}, and high rates of subsequent litigation⁶. It should be regarded as preventable. The advent of laparoscopic cholecystectomy has resulted in a resurgence of interest in bile duct injury and its subsequent management. Population-based studies^{7–9} suggest a significant increase in the incidence of injury (0.1 to 0.5 per cent) following the implementation of the laparoscopic approach^{7–11}.

In the United States¹² and British Columbia¹³ 34–49 per cent of surgeons have caused a major bile duct injury, with an individual experience of one to two such cases^{12,13}. Increasing evidence suggests that such injury should be managed by an experienced hepatobiliary surgeon¹⁴ and that early recognition¹ of injury directly affects outcome. Patients treated by the injuring surgeon have an increased risk of death of 11 per cent at 9 years¹⁵, yet in North America 58–75 per cent of injuries are still

repaired by the injuring surgeon^{3,13}. Significant delays in referral to the appropriate services remain and in the UK over half the patients still undergo attempted repair by inexperienced surgeons¹⁶.

Prevention

Bile duct injury should be regarded as preventable, but over 70 per cent of surgeons regard it as unavoidable¹³. Although most injuries occur within the surgeon's first 100 laparoscopic cholecystectomies¹², one-third happen after the surgeon has performed more than 200; it is more than inexperience that leads to bile duct injury¹². It has been suggested that the commonest cause of common bile duct injury is misidentification of biliary anatomy (70–80 per cent of injuries)^{15,17}. Hunter¹⁸ and Troidl¹⁹ have 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. However,

to apply these techniques, correct interpretation of the anatomy is required. Three quarters of bile duct injuries are not recognized at the time of injury^{15,17}, suggesting that anatomical orientation is a major problem. To overcome this and to facilitate orientation before starting dissection, Hugh¹⁵ recommends identifying Rouviere's sulcus as a fixed extra-biliary point ventral to the right portal pedicle¹⁵. 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. No dissection should occur in the hepatoduodenal ligament at the base of segment IV as the left hepatic duct lies extrahepatically within this tissue²⁰.

Although controversial, there is no randomized controlled trial on the relationship of intraoperative cholangiography and the incidence of bile duct injury, and it is unlikely that one will be conducted given the number of patients required to address this issue. Three population-based studies^{7,11,21} have shown a reduction in risk if surgeons perform routine intraoperative cholangiography, although all are subject to bias. Fletcher *et al.*⁷ report that the risk of injury is reduced eightfold in the presence of complicated gallstone disease. Flum *et al.*²¹ report a twofold reduction in risk of bile duct injury with routine use of intraoperative cholangiography for inexperienced surgeons. The same group¹¹ examined the outcome in more than 1.5 million laparoscopic cholecystectomies and demonstrated that failure to perform an intraoperative cholangiogram increased the risk of bile duct injury by one-and-a-half to seven times, which remained even when adjusted for surgeon and patient factors. They were unable, however, to establish the reasons why an intraoperative cholangiogram was not performed. Routine use of cholangiography is cost-effective²², with maximum efficiency achieved when used by inexperienced surgeons or when complex disease is encountered. Others have argued that bile duct injury^{15,23} is not prevented by cholangiography, and that only meticulous dissection and correct interpretation of anatomy will avoid this complication.

Despite this controversy there is good evidence to show that intraoperative cholangiography is likely to identify the injury at the time of surgery. Archer *et al.*¹² report that 81 per cent of bile duct injuries were detected at the time of initial surgery when a cholangiogram was obtained in comparison to only 45 per cent when it was not employed. This has significant implications for the patient given

the improved outcome associated with early appropriate repair¹.

Diagnosis

Recognition of bile duct injury at the time of cholecystectomy allows an opportunity for the hepatobiliary surgeon to assess its severity and the presence of any vascular injury. Given that as many as 90 per cent of injuries²⁴ will not be diagnosed during surgery, a high index of suspicion is required in patients who become unwell in the early postoperative period. Initial symptoms^{25,26} may be non-specific; patients are discharged from hospital frequently only to reappear a few days later with classical symptoms and signs^{24,27} of biliary leak or transection of the bile duct. These include jaundice, biloma, sepsis, biliary fistula (with or without jaundice) and biliary peritonitis. The median delay in diagnosis is 1–2 weeks^{25,27}, but for stricture it may be months or years²⁷. Late presentation includes recurrent cholangitis and secondary biliary cirrhosis. It has not been established if routine placement of drains allows earlier detection of a bile leak, but any patient remaining unwell 48 h after surgery should be investigated for possible bile duct injury²⁸.

Bile duct injury may present in the same way as commoner but less serious complications of cholecystectomy, and initial management must be dictated by the clinical presentation. Investigations would usually include ultrasonography and liver function biochemistry. After cholecystectomy the incidence of collections in the gallbladder fossa is 10–14 per cent^{29–31}, but the presence of fluid outside the gallbladder fossa should not be dismissed as a normal postoperative finding. Although postoperative increase in alanine aminotransferase occurs in 34 per cent of patients following laparoscopic cholecystectomy³², increases in bilirubin or alkaline phosphatase occur only in 9 per cent and 4 per cent respectively³², and increase in these enzymes after 24–48 h requires re-evaluation of the patient. There is no role for 'blind' laparoscopy or laparotomy in the diagnosis of bile duct injury, but either procedure may be necessary to perform peritoneal lavage and allow placement of drains at the hilus to control biliary peritonitis. Abdominal ultrasonography should exclude ductal dilatation, accepting that the absence of such dilatation does not exclude an injury. Detection of fluid collections mandates aspiration or drainage, irrespective of clinical signs, as undrained bile can be rapidly lethal if left untreated³³. Delay in diagnosis is associated with an increase in serious complications, and the development of infected bile is associated with an adverse outcome²⁶. The presence of bile is diagnostic of a bile duct complication and requires investigation by a high

Table 1 Summary of proposed classifications of bile duct injuries

Reference Year	Bismuth ⁴⁰ 1982	Strasberg <i>et al.</i> ⁴¹ 1995	Stewart <i>et al.</i> ³⁸ 2004	Keulemans <i>et al.</i> ²⁷ 1998	Csendes <i>et al.</i> ⁸¹ 2001	Schmidt <i>et al.</i> ⁴² 2004
Bile Leak						
Cystic duct or terminal biliary radical leak		A		A		A _{1,2}
Bile leak from CBD/CHD without tissue loss		D	I	B1	I,II	C _{1,2}
Bile leak with tissue loss from CHD/CBD			II	B1	III	D ₂
Bile leak from right hepatic duct (posterior sector)		C	IV*	B2		
Transection or occlusion of CBD or CHD			III	D	III	B _{1,2} or D _{1,2}
Strictures						
CBD stricture						E _{1,2}
CHD > 2 cm	I	E1	III	C	III,IV	E ₃
CHD < 2 cm	II	E2	III	C	III,IV	E ₃
Hilar stricture but confluence intact	III	E3	III	C	III,IV	E ₃
Hilar stricture with disruption of confluence	IV	E4	III	C	III,IV	E ₃
Obstructed right posterior hepatic duct with or without CBD/CHD stricture	V	B/E5	IV*	C		E ₄

*Includes the recognition of right hepatic artery injury. CBD, common bile duct; CHD, common hepatic duct.

quality cholangiogram, the nature of which will depend on local experience. Magnetic resonance cholangiopancreatography is generally preferred^{34,35} and should determine the need for endoscopic retrograde cholangiopancreatography if a minor duct leak (small intrahepatic biliary radical or cystic duct leak) or distal obstruction from choledocholithiasis is confirmed. In the event of an excision or transection of a major duct or an isolated segmental duct injury, endoscopic retrograde cholangiopancreatography is not useful and may further delay the diagnosis owing to misinterpretation. If the ultrasonography results are equivocal in a symptomatic patient, computed tomography should be performed as its sensitivity is higher than that of ultrasonography (96 per cent *versus* 70 per cent)²⁶. Following drainage of any collection, contrast studies through the drains may be useful in further elucidating the nature of any injury or leak.

Once referred to a specialist unit for management, an assessment of vascular anatomy is required³⁶ as vascular injury is present in 26–32 per cent of patients^{37,38}. Duplex ultrasonography is unreliable³⁶; magnetic resonance or computed tomography angiography may be preferable to invasive angiography and should exclude injury to both the arterial and portal venous systems and the presence of pseudoaneurysms that may follow sepsis or traumatic injury. Vascular assessment is particularly important if there has been a previous attempt at repair and in the management of more proximal injury, which may be associated with damage to the right hepatic artery^{36,38}. In circumstances of delayed stricture, it is important to assess the quality of the obstructed liver³⁹. Although hepatocellular atrophy does not always occur with arterial

injury alone, it may develop in the presence of long-term obstruction and be associated with the development of fibrosis or cirrhosis. If any such concern exists a liver biopsy should be considered.

Classification

Several classifications (*Table 1*) of bile duct injury have been proposed^{27,40–42}, but none is accepted as a universal standard. None of the early proposed classifications (*Fig. 1*) allowed for the documentation of an associated vascular injury, which has been described only recently³⁸. The heterogeneity of these classifications reduces their clinical utility. Three of the proposed classifications^{27,41,42} include cystic duct or terminal biliary radical leaks, yet these may be better considered as biliary complications rather than injuries, as the chance of long-term morbidity and mortality is low⁴³. In addition, neither the Strasberg *et al.*⁴¹ nor the Bismuth⁴⁰ classification clearly describes one of the most serious injuries, namely that which presents as a biliary leak with separation of the right and left ducts resulting from excision of the extrahepatic biliary tree. Although classifications are useful for standardization of outcome and predictive quality, the current versions fail to take into account important short-term prognostic factors, including mode of presentation⁴⁴, attempts at previous repair¹⁴, presence of concomitant sepsis⁴² and stability of the patient⁴⁵.

Management

Management depends on the timing of recognition of injury and may be considered as intraoperative, early and delayed.

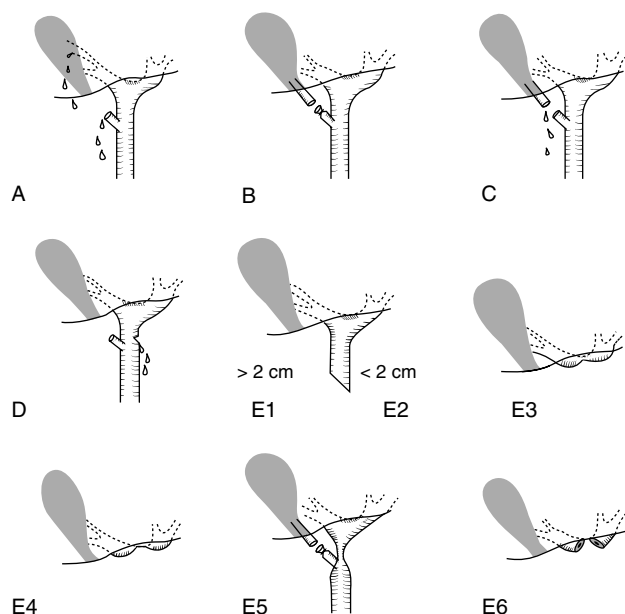


Fig. 1 Schematic representation of the Strasberg *et al.*⁴¹ classification of bile duct injuries. A Bile leak from cystic duct stump or minor biliary radical in gallbladder fossa. B Occluded right posterior sectoral duct. C Bile leak from divided right posterior sectoral duct. D Bile leak from main bile duct without major tissue loss. E1 Transected main bile duct with a stricture more than 2 cm from the hilus. E2 Transected main bile duct with a stricture less than 2 cm from the hilus. E3 Stricture of the hilus with right and left ducts in communication. E4 Stricture of the hilus with separation of right and left ducts. E5 Stricture of the main bile duct and the right posterior sectoral duct. E6 complete excision of the extrahepatic ducts involving the confluence (this injury is not described in Strasberg's classification)

Intraoperative management

If a bile leak from a duct is identified within the proximal gallbladder fossa or hilum, a major injury should be suspected and advice sought, as it is known that outcome is improved when an experienced hepatobiliary surgeon is present^{3,14}. If such assistance is unavailable, transfer of the patient should be considered after adequate drainage is achieved by large-bore drains. Injudicious attempts at exploration of the bile leak by laparoscopic means or at open operation should be avoided, as any injury may be exacerbated by forceful cannulation and retrograde on-table cholangiography. Interpretation of cholangiography is of particular importance and failure to identify the right posterior sectoral ducts should alert the surgeon to the likelihood of a concomitant isolated segmental

injury. While ligation of a terminal biliary radical may be undertaken safely following cholangiography, ligation of a significant isolated segmental branch may result in obstructive segmental cholangitis, hepatic abscess and prolonged biliary fistula. If cholangiography demonstrates a major duct injury, reconstruction in the form of a hepaticojejunostomy is required. Despite one recent report⁴⁶, a choledocho- or hepaticoduodenostomy should not be performed as there is an almost universal need for revision because of recurrent cholangitis⁴⁷.

Biliary reconstruction is best performed by a specialist surgeon^{3,14}; primary repair over a T-tube may result in failure¹⁴. In a review of 88 patients¹⁴ with bile duct injury after laparoscopic surgery; only 17 per cent of repairs were successful in those performed by a non-tertiary level hepatobiliary surgeon compared with 94 per cent of those performed by a specialist, and the hospital stay was three times longer when managed by a non-specialist surgeon (78 days *versus* 222 days). The morbidity and mortality of those treated by a non-specialist compared with a specialist was 58 and 1.6 per cent *versus* 4 and 0 per cent respectively. These data are supported by the larger Medicare cohort study reported by Flum *et al.*³, who showed a poorer survival outcome in patients undergoing repair by the injuring surgeon.

The effect of the increased duration of illness experienced by those in whom referral is delayed warrants further comment. The presence of biliary peritonitis is an independent factor for poor outcome⁴⁴, and hepatic fibrosis can occur within 6–12 months of injury without adequate management³⁹. This is particularly concerning as cirrhosis and portal hypertension significantly increase mortality after bile duct injury⁴⁵. Importantly, duration of treatment is also an independent prognostic factor for quality of life after attempts at repair⁴ so delay should be minimized.

Early postoperative management

For a partial defect in the duct, the best option is primary closure with fine absorbable sutures and subhepatic drainage, rather than placement of a T-tube; experience in liver transplantation has shown that a T-tube placed within a choledocho-choledochostomy is associated with a significantly higher stricture rate than with repair without a T-tube (25 per cent *versus* 11 per cent)⁴⁸. Although T-tube placement at a site remote from the injury seems sensible, it may be prudent to avoid a foreign body in a non-dilated damaged duct. Endoscopic stenting or sphincterotomy can be performed^{27,49} in the event of postoperative bile leak and have a 57–70 per cent chance of success^{14,27}. However, the real outcome is difficult to know as the real denominator in this setting is unknown, and few studies report long-term follow-up.

Primary repair of a major duct injury has a prospect of success if done within the first few days. The surgeon must be satisfied that the entire biliary tree is identified and assess any associated vascular injury, particularly in the presence of a proximal injury³⁶. Bilioenteric anastomosis to healthy mature tissue has been advocated in a non-infected environment⁵⁰. Success is most likely when the anastomosis is performed as proximally as possible on the extrahepatic ducts so as to provide as wide and well vascularized anastomosis as possible^{51,52}. The so-called 'mucosal graft technique', popularized by Smith in the 1960s^{53,54}, involves creating a pouting mucosal dome of jejunum on the apex of a Roux limb through which a rubber tube is brought and fed retrogradely via the hepatic ducts and through the liver substance. It is theorized that the mucosa grafts to the biliary epithelium. Although Smith described good short-term results, long-term follow-up has been lacking⁵³. In the subsequent 40 years there have been few reports^{55,56} in the literature to support the use of the technique^{2,45,57} and there seems little rationale for its continued use.

The best results are achieved by hepaticojejunostomy^{14,58,59}, yet this also has a failure rate⁵¹, particularly when performed by an inexperienced surgeon¹⁴. Factors associated with an improved outcome include the use of absorbable sutures, single-layer anastomoses and debridement back to healthy non-inflamed or scarred tissue¹⁴. Attention to the anatomical placement of the anastomosis is important^{52,57,60}, as failure after hepaticojejunostomy is usually because of an anastomotic stricture⁵¹, which is often ischaemic in nature⁵². In the setting of bile duct injury, the common hepatic duct is generally thin walled and not dilated more than 7 mm, so an end-to-side anastomosis results in a narrowed luminal diameter. This can be avoided by using the left duct approach⁶⁰⁻⁶², which involves exposing the left hepatic duct along its extrahepatic course at the base of segment IV (Fig. 2). The anterior surface of the left hepatic duct can be exposed by incising Glisson's capsule and dissecting overlying hepatic parenchyma at the base of segment IV without risking significant bleeding since the main vessels lie posteriorly. The dissection must not be taken too far to the left, as the arterial branch to segment IV invariably runs anteriorly from the left hepatic artery. Opening the left hepatic duct longitudinally creates the basis for a wide anastomosis (1–3 cm), which incorporates the orifice of the right and left segmental ducts; the operating surgeon must be conscious of aberrant ductal anatomy, such as the segment IV duct entering close to the bifurcation⁶³. A posterior approach⁶⁰ is possible by incising the parenchyma of the caudate process, which allows the

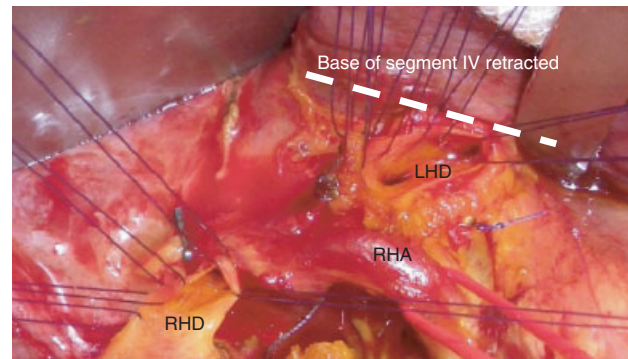


Fig. 2 Left hepatic duct opened out in preparation for hepaticojejunostomy after E6 bile duct injury sustained during laparoscopic cholecystectomy. RHD, Right hepatic duct; RHA, right hepatic artery intact; LHD, left hepatic duct with orifice of segment IV and II/III

whole hepatic hilum to be slung and distracted from deep within the hepatic parenchyma. Lillemoe *et al.*⁵⁹ prefer an end-to-side anastomosis with postoperative transanastomotic stenting, but this requires further invasive manipulation of the stents over a minimum of 9 months in most patients. Thirteen of 142 (9 per cent) patients so treated required further intervention for recurrent strictures. The use of postoperative transanastomotic stents is not accepted universally⁶⁰. Advocates of stenting suggest that these maintain anastomotic patency and decompress the biliary tree in the advent of oedema at the anastomosis, yet biliary stents are known to cause an inflammatory reaction and so are more likely to promote scar formation⁶⁴. If stents are to be used, it may be better to place them proximal to the anastomosis without traversing the repair⁶⁰.

Despite increasing evidence that early repair is associated with a shorter duration of treatment¹⁴ and subsequent improved quality of life⁴, the timing of intervention remains a controversial issue^{58,65}. Chaudhary *et al.*⁵¹ noted that repair within the first 3 weeks is associated with an increased risk of failure, but they did not document how many repairs were performed by an experienced operator. In contrast, Thomson *et al.*⁶⁶ have recently reported a large series of 114 patients, of whom 64 had not undergone prior repair. Of these 64 patients, 22 underwent repair within the first 2 weeks of injury and only one required further surgical intervention. On the other hand, 37 (74 per cent) of 50 patients undergoing repair by the primary surgeon required further surgery subsequently. If the criteria for a successful anastomosis cannot be met, as in the event of disruption of the confluence with an associated vascular injury, or significant diathermy injury, or surrounding sepsis, it may be prudent to delay repair and establish a

controlled fistula. This allows the final level of the injury to demarcate, determines the need for concomitant hepatic resection, and allows the ducts to dilate and mature to improve the likelihood of a successful result^{51,67}.

Delayed management

Initial treatment should focus on resuscitation of the patient, drainage of any collections to create a controlled enterocutaneous fistula and treatment of sepsis. Nutritional support should be maintained during subsequent definition of the anatomy and definitive repair.

Drainage of collections

This can usually be performed percutaneously, although in the presence of widespread biliary peritonitis or intra-abdominal contamination, surgical lavage and placement of drains is likely to be required. It is generally accepted that it is useful to obtain proximal control with a percutaneous transhepatic external biliary drain⁶⁸. Any intra-abdominal drains may be withdrawn subsequently from the hilum, reducing inflammation from such a foreign body, thereby allowing the tissue to mature⁶⁸. They may promote stricture formation within the injured biliary tree and subsequent biliary dilatation. The positioning of a percutaneous transhepatic catheter in the absence of dilated ducts can be difficult and it may be necessary to wait until intrahepatic dilation occurs. In the event of separation of the confluence, more than one drain may be required⁶⁸.

Nutrition

Delayed diagnosis of bile duct injury may result in a systemic inflammatory response, with subsequent development of multiorgan failure from biliary peritonitis. Low serum levels of albumin at the time of surgery are associated with a poorer outcome⁴⁵, and it is important to address any nutritional deficit with enteral feeding. Long periods of biliary–enteric discontinuity are associated with impaired function of the intestinal barrier⁶⁹ and increase the risk of endotoxaemia⁷⁰. In the long term, there is also a risk of fat-soluble vitamin deficiency, and bile refeeding⁶⁹ should be considered to overcome this, particularly in patients receiving enteral nutrition.

'Minor' bile duct injury or biliary complication

Having confirmed radiologically a terminal biliary radical or cystic duct leak, the treatment of choice is endoscopic retrograde cholangiopancreatography and sphincterotomy⁴⁹ or endoscopic stenting²⁷. It has been suggested that a repeat endoscopic retrograde cholangiopancreatography should be performed at 6 weeks after

stenting, with removal of the stent if no further leak or stricture is seen. In 88–94 per cent of patients a good outcome is obtained^{27,49}. This approach can also be used where there is minimal tissue loss of the main bile duct, such as avulsion of the cystic duct with no associated stricture, but the long-term success is reduced to 70 per cent²⁷.

Major bile duct injury

Delayed recognition of a major bile duct injury results in sepsis and/or a major inflammatory response; early definitive repair should not be done as results are poor¹⁴. It is preferable to wait 3 months until the patient is well and in an anabolic state⁶⁷. If the biliary confluence is intact and there is no associated vascular injury, a hepaticojejunostomy on to the extrahepatic left duct gives the best result^{51,60,71,72}. Murr *et al.*⁷¹ report a 91 per cent success rate and an 88 per cent 5-year stricture-free survival. However, with associated right hepatic artery injury anastomosis to the right duct produces a less satisfactory outcome with recurrent segmental cholangitis³⁶. It may, therefore, be appropriate to consider a right hemihepatectomy⁷³. It is only recently that the problems associated with vascular injury have been highlighted^{20,36,37,42}. There is a high failure rate after primary repair although the extent of this is not known because of lack of reporting of vascular status in earlier studies. In liver transplant surgery, biliary complications are almost universal following hepatic artery thrombosis⁷⁴. However, two recent studies have questioned the view that associated arterial injury influences outcome in bile duct injury repair following cholecystectomy^{38,75}. A prospective study of 54 patients, which employed the left duct approach to bile duct repair, showed no difference in outcome between those with and without arterial injury⁷⁵. The same study also demonstrated rapid collateralization of the distal right hepatic stump via the hilar plate. In a larger retrospective study, 84 patients with bile duct injury and definite evidence of a right hepatic arterial injury were compared with 177 patients with assumed normal vascular anatomy³⁸. When associated with a right hepatic artery injury repaired by the primary surgeon, complications and failure of the repair were high (41 and 85 per cent respectively); however, they were not different to those achieved by a primary surgeon in the absence of right hepatic artery injury. In contrast, in those with a right hepatic artery injury repaired by a hepatobiliary surgeon, the overall success of the repair was 93 per cent and morbidity 5 per cent. Only four of the 84 patients eventually required a right hepatectomy. Hepatic necrosis results in the presence of biliary obstruction and arterial injury⁷⁶, whereas an isolated arterial injury is

usually tolerated without clinical sequelae⁷⁷. It is possible, therefore, that failure of the reconstruction following repair by primary surgeons is due to technical problems, such as failure to identify and include the right-sided ducts into the anastomosis⁶⁰ or failure to construct a wide biliary anastomosis using extension onto the left duct⁷⁵, thereby promoting stricture of the anastomosis and right-sided biliary obstruction.

An isolated right hepatic duct injury may present with ongoing biliary leak despite an endoscopic retrograde cholangiopancreatography interpreted mistakenly as showing no biliary leak. In this setting, percutaneous drainage of the isolated segment allows proximal control of the biliary leak and subsequent guidance at the time of cholangiojejunostomy. Lillemoe *et al.*⁷⁸ reported nine such injuries; three patients eventually developed cholangitis and required percutaneous dilatation. In some situations, hepatic resection is a preferable option⁶⁶. For patients with very high injuries with disruption of the confluence, Lillemoe *et al.*⁶⁸ have described a technique similar to that used for a left-sided approach. By resecting the base of the gallbladder fossa, the right ducts are exposed to allow separate anastomoses to be fashioned. Multiple biliary anastomoses should be treated as one anastomosis, placing all the anterior row of sutures before placement of the posterior row to all ducts under direct vision. The jejunum can then be parachuted into apposition with the separated ducts⁷⁹. It is imperative that a thorough search be made for any missing sectoral ducts, as draining segments may be excluded from the anastomosis⁶⁰. None of 22 patients with isolated right sectoral injury or with disruption of the confluence treated with this technique has needed further intervention or suffered from recurrent problems at a median follow-up of 3 years⁶⁷.

In those who present late with complications from recurrent strictures it is important to assess residual liver function. Those who have developed secondary biliary cirrhosis may be candidates for liver transplantation rather than for further reconstruction, especially if there is significant portal hypertension.

Endoscopic stenting

Although endoscopic stenting has a role in the management of minor injuries where there is no stricture or anatomical deficit, its results are generally poorer than those of surgery. Stewart and Way¹⁴ reviewed 29 patients who underwent endoscopic management in the form of balloon dilatation or stenting. This was successful in only seven patients, with a median duration of treatment of 110 days if it was successful and 297 days if not. The mean duration

of illness in those managed with endoscopic treatment was 584 days compared with 177 days in those treated with surgery alone. In a report by Bonnel *et al.*⁸⁰, of 25 patients submitted to metal stenting for recurrent anastomotic strictures, over half developed recurrent problems during follow-up. The authors concluded that metal stenting should be used only when further surgery is contraindicated. Csendes *et al.*⁸¹ reported on the endoscopic management of 94 patients but provided detailed long-term follow-up only for 49 patients; while 76 per cent had a satisfactory outcome at 3 years, these results are not as good as those achieved by surgery^{14,68}. Similarly, Lillemoe *et al.*⁶⁸ found a long-term success rate with balloon dilatation for biliary strictures of only 64 per cent, although a combination of techniques was often required to achieve optimal results. In a more recent report from the same institution, Misra *et al.*⁸² describe the outcome of 51 patients who were managed with radiological stenting. Thirty patients had a good outcome at a median follow-up of 77 months. Percutaneous management, particularly of proximal injuries, was more likely to fail in those stented for less than 4 months. It is difficult to establish whether the duration of stenting was truly an important factor or a reflection of the fact that those more likely to fail were identified early and converted to surgical management. Of 21 patients who failed percutaneous management, 18 underwent surgery with a successful outcome. These results suggest that endoscopic or percutaneous intervention may provide a useful adjunct to surgery in certain situations.

Follow-up

Long-term follow-up is important, as delayed and recurrent complications are common. In a report of 72 patients followed for 10 years⁴⁷, 25/43 of those who had undergone an end-to-end bile duct repair had required further surgery compared with 16/47 of those repaired with a choledocho- or hepaticojejunostomy. Those more likely to develop problems included patients with more proximal injuries and those who had undergone immediate repair, although only four of 22 patients who underwent repair had a hepaticojejunostomy. Less than a third of recurrent strictures occurred within the first 3 years, and the authors recommended at least 10 years of follow-up⁴⁷. In a more contemporary study⁸³, 33 patients were followed for a minimum of 3 years with a mean of 6.5 years. Twenty-one patients had no further problems during the follow-up period, the rest having further episodes of cholangitis requiring intervention. The probability of developing ongoing symptoms was directly related to the

level of injury, with five of six patients whose initial injury consisted of hilar disruption (Bismuth level IV) requiring further intervention and five of 13 with Bismuth level III injuries also requiring further action. Interestingly, those with more severe injuries presented earlier with recurrent problems, usually within the first 2 years.

Quality of life

Despite the excellent functional and anatomical results that can be achieved by early referral and appropriate primary repair, the same cannot be said for quality of life. In one of the first studies assessing quality of life after bile duct injury, Boerma *et al.*⁴ assessed the outcome in 89 patients who had undergone bile duct injury repair. The median follow-up was 70 months. The study included 70 patients with major biliary injury of whom 37 were treated endoscopically. Paradoxically, a type A injury (Fig. 1) was associated with a poorer quality of life. On univariate analysis, endoscopic treatment and the duration of treatment were associated with a worse mental quality of life. Only duration of treatment was associated with a poorer mental quality of life with multivariate analysis. Further studies^{5,84} have confirmed a reduced quality of life in terms of psychology. Melton *et al.*⁸⁴ have also shown that patients who are involved in legal proceedings have a poorer quality of life; it is not known whether this improves after settlement. These studies^{4,84} often used endoscopic or transanastomotic stenting to treat major bile duct injuries rather than a left duct technique. In a more recent series from a unit predominantly using a left duct approach, the quality of life for patients who had suffered a bile duct injury was equivalent to that of the general population⁸⁵. However, this series specifically excluded patients for whom litigation was pending, and all were more than 5 years from their injury.

Conclusion

Laparoscopic cholecystectomy has become the treatment of choice for symptomatic cholelithiasis, and it is associated with an increase in incidence of bile duct injury. Despite an increasing awareness of this problem, yet more attention should be paid both to prevention and to early recognition of such injury. Available evidence suggests that after recognition of a bile duct injury, the patient should be immediately referred to a surgeon with experience in the management of such iatrogenic pathology. A proximal hepaticojejunostomy is the treatment of choice for most patients. Long-term follow-up is required.

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