

Bile duct injury following laparoscopic cholecystectomy

Iatrogenic biliary injury following laparoscopic cholecystectomy is uncommon, but carries considerable morbidity and often requires complex management. Biliary injuries require a multidisciplinary approach, with radiological, endoscopic and operative interventions all playing a significant role in their subsequent management.

Laparoscopic cholecystectomy is the treatment of choice for uncomplicated, symptomatic gall-stones. Although iatrogenic injury to the biliary tree can be associated with any operations in the upper abdomen, it is generally seen following laparoscopic cholecystectomy. The bile duct injury can be identified at the time of original commission, over the next few days or some weeks to months later. Unrecognized or inadequately treated injuries lead to bile duct stricture, with a lifelong risk of cholestasis and potentially liver failure. All iatrogenic injuries should be managed in a multidisciplinary manner, with interventional radiology, endoscopy and operative intervention considered as therapeutic options.

Gall-stones

Gall-stones are common: for men the incidence increases from 6.5% between 30–69 years of age to 24% at 90 years and for women increases from 10.5% between 30–69 years of age to 35% at 90 years (Attili et al, 1995). Most stones are asymptomatic, but 1–4% of patients per year develop symptoms (Gurusamy and Davidson, 2010). Cholecystectomy remains the treatment of choice for symptomatic, uncomplicated gall-stone disease (Nordin et al, 2011); dietary modification, medical, endoscopic and radiological drainage decrease, but do not eliminate, the risk of gall-stone-related complications.

Operative anatomy

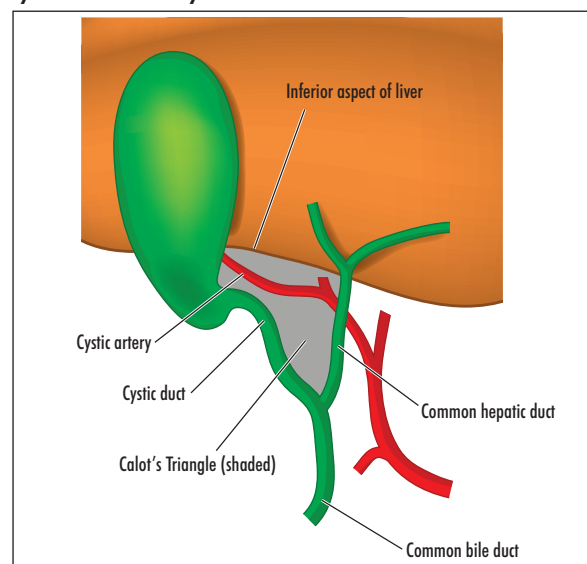
The gall bladder has three sections – the fundus, body and neck – and lies within a fossa between the quadrate and right lobes of the liver. Bile exits via the cystic duct, which joins the common hepatic duct to form the common bile duct. Gall-stones can become lodged within a mucosal fold at the neck of the gall bladder (Hartmann's pouch) and cause intermittent obstruction and pain – biliary colic. Infection of the gall bladder (cholecystitis) results in constant pain, with constant obstruction to the flow of bile resulting in mucocele formation; both infection and obstruction together can cause an empyema of the gall bladder to develop. Rarely large gall-stones can cause dilatation of Hartmann's pouch and external compression of the biliary tree (Mirizzi's syndrome).

A single cystic artery usually supplies the gall bladder (in approximately 70% of patients), which arises from the right hepatic artery. Most bile enters the gall bladder retrogradely via the cystic duct, but subvesicle bile ducts (ducts of Luschka) may exist that drain directly from the liver into the gall bladder. If these ducts are in communication with intrahepatic radicals of the right hepatic ductal system then they may leak bile after cholecystectomy.

The cystohepatic triangle (triangle of Calot) is of paramount importance for cholecystectomy (Figure 1). This triangle is bound by the cystic duct, common hepatic duct and the liver margin; it contains the cystic artery and a solitary lymph node (Lund's node). Full exposure of Calot's triangle to produce the 'critical view of safety' is advocated to reduce the incidence of iatrogenic biliary injury (see below). Standard laparoscopic cholecystectomy involves identification and ligation of the cystic artery and duct before resection of the gall bladder from its fossa; alternatively fundus-first cholecystectomy can be performed if Calot's triangle cannot be fully visualized.

Standard laparoscopic cholecystectomy involves identification and ligation of the cystic artery and duct before resection of the gall bladder from its fossa; alternatively fundus-first cholecystectomy can be performed if Calot's triangle cannot be fully visualized.

Figure 1. Schematic showing the critical view of safety: Calot's triangle 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 seen, the only two structures entering the gall bladder must be the cystic duct and artery.



Mr JML Williamson is Speciality Training Registrar in the Department of Hepato-Pancreato-Biliary Surgery, Bristol Royal Infirmary, Bristol BS2 8HW (jmlw@doctors.org.uk)

Incidence of iatrogenic biliary injury

The incidence of bile duct injury following laparoscopic cholecystectomy ranges from 0.33–0.5% (Karvonen et al, 2007; Gurusamy and Davidson, 2010), despite efforts to standardize the technique and an awareness of complications (Nordin et al, 2011). This is higher than the 0.2% incidence reported for open cholecystectomy, which may be an underestimate; in the era of open operation some injuries were probably recognized and dealt with at the time, thereby escaping reoperation (Fletcher et al, 1999; Tantia et al, 2008; Sahajpal et al, 2010).

Two-port laparoscopic surgery, single incision laparoscopic surgery and natural orifice transluminal endoscopic surgery are being developed as methods for cholecystectomy to improve recovery and reduce postoperative pain and scarring. These techniques are not widely used and thus have associated learning curves and increased risk of biliary injury. Single incision laparoscopic surgery, for example, has a 0.7% risk of ductal injury (Joseph et al, 2012).

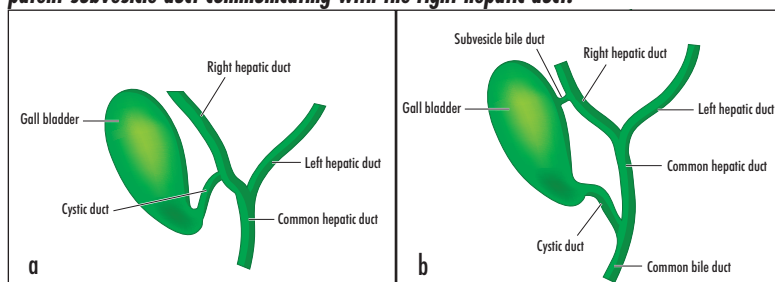
Timing of operative intervention

Timing of cholecystectomy depends upon symptoms, the probability of pericholecystic inflammation and the availability of theatres and surgeons. Generally cholecystectomy can be either performed in the elective setting or as an emergency procedure either during, or within 2 weeks of, presentation (i.e. ‘early cholecystectomy’). Some surgeons have concerns that early cholecystectomy may increase the risk of iatrogenic injury, but there is no significant difference in rates of injury; it is also associated with lower conversion rates, shorter operating times, and shorter post-operative length of stay (Gurusamy et al, 2008). The lack of surgeon and theatre availability may mean that cholecystectomies cannot be performed during the index admission, so are listed on an elective list; these patients have further gall-stone-related complication rates of 20–50% before the definitive operation (Duncan and Riall, 2012).

Risk factors for iatrogenic biliary injury

Laparoscopic cholecystectomy can be straightforward, but a number of factors influence the risk of iatrogenic injury, many of which can be lessened by awareness, operator skill and technique. Risk factors can be subdivided into those relating to the patient and those which develop intraoperatively (Strasberg, 2002; Nordin et al, 2011).

Figure 2. Schematic showing (a) the cystic duct entering the right hepatic duct and (b) a patent subvesicle duct communicating with the right hepatic duct.



Patient factors

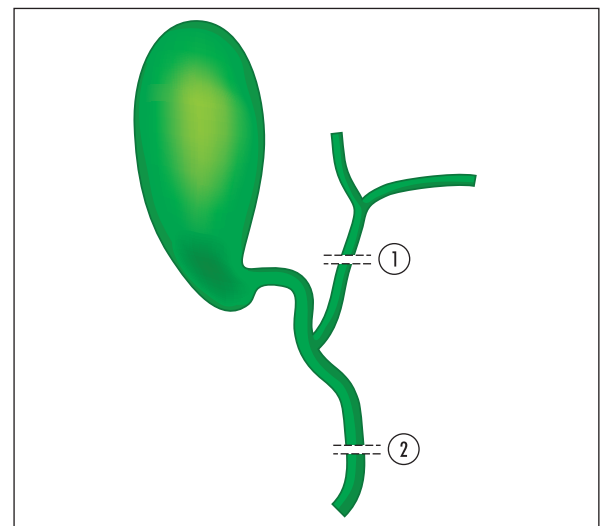
Anatomical anomalies of the biliary tree are common. They present a significant challenge and carry an increased risk of iatrogenic injury (Sahajpal et al, 2010). Although a short cystic duct can reduce the space available within the operating field, the most common problem is an aberrant right hepatic duct (seen in 2% of the population) (Figures 2a and b) (Strasberg, 2002). This can be misidentified by the unwary surgeon with deleterious consequences (see below). Obesity brings an increased risk of iatrogenic injury; the bulk of the patient may restrict access, enlarged fatty livers may obscure biliary anatomy and increased fat deposition within Calot’s triangle requires further dissection. Patients should be advised to lose weight before intervention and a liver-reducing diet (low in carbohydrate and fat) can be considered to reduce liver bulk.

Bile duct injury is more common with a difficult dissection but can complicate an ‘easy’ operation (Nordin et al, 2002). Acute or chronic inflammation around the gall bladder and hepatoduodenal ligament can make a laparoscopic procedure more technically difficult, with more risk of injuring the ducts. Chronic inflammation can cause dense scarring, obscuring landmarks in Calot’s triangle. Other factors predisposing to bile duct injury include fat within the hepatoduodenal ligament, poor exposure and intra-operative bleeding (Strasberg, 2002; Tantia et al, 2008).

Intraoperative factors

Most bile duct injuries (70–80%) arise from a failure to identify the anatomy before clipping (or ligation) and then division of a ductal structure (Figure 3) (Callery, 2006). Misidentification arises in two main scenarios: either the main bile duct is mistaken for the cystic duct and divided, or an aberrant right hepatic duct is thought to be the cystic duct (Nordin et al, 2011). Both errors

Figure 3. Schematic showing (1) misidentification of the common hepatic duct and subsequent division (presumed cystic duct) followed by (2) division of the common bile duct to allow excision of the gall bladder – often thought of as division of an ‘accessory duct’.



require a second division of the bile duct (or right hepatic duct) to complete the cholecystectomy, the surgeon suspecting a 'second cystic duct' or an 'accessory duct'.

Excessive dissection can also cause ductal injuries either by diathermy burns or skeletonising the common bile duct (damaging the axial arteries) resulting in ischaemic stricture formation (Callery, 2006). Faulty instrumentation or diathermy technique may result in thermal injuries to surrounding structures, and direct trauma (by grasping forceps) can have a similar effect. A diathermy burn to the bile duct may not reveal itself until the areas of coagulative necrosis give way postoperatively (Strasberg, 2002).

Technical aspects can influence the risk of iatrogenic injury. Surgical inexperience can increase the risk, as can over-confidence. Laparoscopic clips must be deployed correctly and securely fastened; ligature loops can be used if thick ducts are encountered. Use of multiple clips is not recommended as this can tent up the ducts (Strasberg, 2002). The gall bladder must be dissected from its fossa in the correct plane to prevent injury to the intrahepatic ducts or veins which may lie superficially in the liver parenchyma.

Strategies to reduce risk of biliary injury

There are several techniques for minimizing iatrogenic biliary injury. They focus on positive identification of the cystic duct and artery as they join the gall bladder neck before any major structure is divided. Dissection of Calot's triangle to ensure the 'critical view' (*Figure 1*) can also reduce the risk of inadvertent ductal injury (Strasberg et al, 1995). Calot's triangle should be cleared of fat and fibrous tissue, with the lowest part of the gall bladder separated from the cystic plate and only two structures identified entering the gall bladder. If this critical view is not met, open surgery should be considered (Joseph et al, 2012).

Use of intraoperative cholangiography or ultrasonography varies widely (Duncan and Riall, 2012). Intraoperative cholangiography and ultrasonography may not prevent injuries, because a certain amount of dissection is needed to identify the ducts, but they can facilitate early detection of the problem (Fletcher et al, 1999; Biffl et al, 2001; Flum et al, 2001). Cholangiography can definitively detect common bile duct stones, may prevent major bile duct injury and can minimize the extent of injury. However, routine use of cholangiography is associated with increased length of operation, costs and complication risk. Selective use of cholangiography is advocated during difficult dissection, when aberrant anatomy is encountered or when the critical view of safety has not been achieved. However, surgeons not performing regular cholangiography may have difficulty in interpreting the findings (Nordin et al, 2011).

During the difficult cholecystectomy an intraoperative opinion from a colleague should be considered as this may decrease the risk of inadvertent injury (potentially as a result of improved structure recognition) (Nordin et al, 2011). Conversion to open cholecystectomy, subtotal cholecystectomy, aborting the operation and placing a cystostomy tube are all options to decrease the risk of bil-

itary injury (Nordin et al, 2011). Resection of the distal portion of the gall bladder, i.e. a subtotal cholecystectomy, removes any calculi while preserving the neck of the organ and thus prevents injury to the biliary tree; a drainage tube to the residual gall bladder can be placed (usually a Foley catheter) to allow external drainage of bile until subsequent fibrosis closes any defects in the gall bladder wall.

T-tubes can be used to help drainage if ductal structures are perforated. This prevents stasis and decompresses the biliary tree while minimizing the risk of leakage. Subsequent endoscopic retrograde cholangiopancreatography and sphincterotomy can be used to encourage bile to flow into the bowel, and a t-tube cholangiogram performed to check resolution of biliary leakage before drain removal.

Presentation

The timing of the diagnosis of a bile duct injury can be classified as immediate (within 72 hours of operation), intermediate (3 days–6 weeks) or delayed (beyond 6 weeks). Unless the injury is detected intraoperatively, there is typically a delay of 3–16 days in diagnosis, primarily because sterile bile within the peritoneal cavity is continuously reabsorbed and thus produces surprisingly few symptoms at first. Patients who fail to recover following discharge or who develop progressive vague abdominal symptoms, nausea, vomiting or jaundice should be evaluated for biliary injury (Nordin et al, 2011).

Immediate

Only 25–30% of iatrogenic injuries are seen during cholecystectomy (Carroll et al, 1998; Gouma and Obertop, 2002), although intraoperative cholangiography can increase this (Nordin et al, 2002). Intraoperative suspicion of a bile duct injury (extravasation of bile from a visible injury or occult source) allows conversion to an open operation and repair by an experienced surgeon (Stewart and May, 1995). Postoperatively, the presence of bile in subhepatic drains is the usual clue to a ductal injury; a persistent leak of more than 50–100 ml/day is unlikely to be the result of an accessory cholecystohepatic duct of Luschke.

Intermediate (72 hours–6 weeks)

The majority of patients with biliary injury are in this group (Nordin et al, 2011), most present with abdominal pain and fever as a result of the presence of a biloma (subhepatic bile collection) or abscess. Those who develop biliary ascites belong in this intermediate category, as do those in whom a clip has been placed across the main bile duct with resultant obstructive jaundice.

Delayed (more than 6 weeks)

Approximately 70% of iatrogenic injuries are detected within 6 months of injury and 80% within 12 months (Hall and Pappas, 2004). The possibility of a bile duct injury should be considered in any patient who develops abnormal liver function tests or jaundice following cholecystectomy and is typically a result of stricturing.

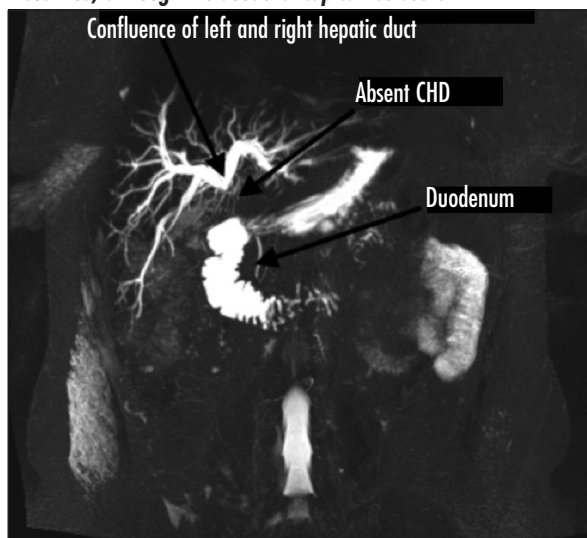
Investigations

Investigation of suspected (iatrogenic) bile duct injury uses either magnetic resonance cholangiopancreatography (where fluid within the biliary tree acts as a contrast medium) or endoscopic retrograde cholangiopancreatography, which allows therapeutic intervention. Percutaneous transhepatic cholangiography has been superseded by magnetic resonance cholangiopancreatography as a diagnostic modality although it plays a significant therapeutic role either alone or in combination with endoscopic retrograde cholangiopancreatography.

Haematological, radiological and nuclear medicine investigations are purely diagnostic. Blood tests may detect signs of an inflammatory response or derangement of liver function (including hypoalbuminaemia and derangement of clotting function) depending on the degree of biliary stricturing. Ultrasound and computed tomography are often used as first-line diagnostic tools and can show extrahepatic bile collections (bilomas or abscesses) or dilated ducts, which can be scanned serially if required.

Magnetic resonance cholangiopancreatography is used extensively for iatrogenic injuries and should be recommended in all cases (Figure 4). It allows assessment of the entire biliary tree, which may not be possible via endoscopic retrograde cholangiopancreatography. If there is a large bile leak, or very tight stricture, retrograde cholangiopancreatography will be unable to delineate the proximal ductal system – essential in planning subsequent management (Williamson, 2013). Magnetic resonance cholangiopancreatography is highly sensitive (85–90% accuracy) and more widely available than endoscopic retrograde cholangiopancreatography (Gupta et al, 2004). Scintigraphy is highly sensitive for revealing the presence and location of

Figure 4. Magnetic resonance cholangiopancreatogram showing complete common hepatic duct (CHD) transection following laparoscopic cholecystectomy. Both left- and right-sided intrahepatic ducts are dilation, but there is no contrast below the confluence – the common bile duct or cystic duct cannot be visualized, although the duodenal cap can be seen.



any active extravasation, although delayed scans at 4 hours are essential to demonstrate a slow leak (Gupta et al, 2004).

Classification of injury

Bile duct injuries can be formally classified using either the five-part Strasberg classification, which characterizes injuries from minor to severe, or the Bismuth classification, which characterizes iatrogenic injuries (Bismuth, 1982; Strasberg et al, 1995). These systems influence management by highlighting cases that can be managed non-operatively and by planning the type and location of repair. More simplistically McMahon et al (1995) divided iatrogenic injuries into minor (partial bile duct tears) and major (including bile duct laceration, bile duct transection or excision and bile duct stricture) to guide management.

Management

The management of patients is highly dependent on when the iatrogenic injury is detected. Intraoperative detection of ductal injury presents the surgeon with a dilemma of immediate repair or extensive drainage of the biliary tree, often with the use of a t-tube, to enable further definitive management. The surgeon's experience is crucial and advice on immediate management should be sought from a specialist hepatopancreatobiliary surgeon.

All injuries detected post cholecystectomy should be discussed at a specialist hepatopancreatobiliary multidisciplinary meeting to allow review of the operation and subsequent investigations as well as planning which therapeutic intervention to perform and when. The extent of injury, the expertise of the surgeon, the amount of acute inflammation in the area and the haemodynamic stability of the patient are the most important factors in achieving a successful repair (Nordin et al, 2011). The types of intervention to consider are endoscopic, radiological and operative.

Endoscopic

Endoscopic retrograde cholangiopancreatography has both a diagnostic and therapeutic role: it displays the exact site of bile duct disruption and allows stent placement (Figures 5 and 6). Retrograde cholangiography may not delineate the ducts proximal to any sites of disruption or occlusion (so collaborative imaging should be used) and stenting in these cases may need a 'rendezvous procedure' (see below).

Insertion of a biliary prosthesis, with or without sphincterotomy, via endoscopic retrograde cholangiopancreatography is the most commonly used non-operative therapeutic intervention for iatrogenic ductal injury. Transpapillary stenting decreases the pressure gradient across the sphincter of Oddi and thus aids closure of a post-cholecystectomy leak, e.g. from the cystic duct stump (Fouch et al, 1993). Large bile leaks usually require stent placement, whereas small leaks can be managed by sphincterotomy alone (Bajaj et al, 2006). Some advocate temporary biliary stenting alone as the best endoscopic intervention for biliary leakage as this avoids potential complications of endoscopic sphincterotomy (Kaffe et al, 2005).

The success of endoscopic retrograde cholangiopancreatography depends on the grade of injury; generally as the severity of injury increases the efficacy of endoscopic retrograde cholangiopancreatography as a curative procedure decreases (although it can still be used to assist in biliary diversion) (Karvonen et al, 2007). Complications include cholangitis, pancreatitis, perforation of the bile duct and either occlusion, migration or dislodgement of the stent. Despite its limitations, definitive treatment with endoscopic retrograde cholangiopancreatography can be achieved in half of all cases (Nordin et al, 2011).

Radiological

Percutaneous transhepatic cholangiography

Percutaneous transhepatic cholangiography is mostly indicated for difficult cases of hilar strictures or very small bile ducts and it can be effective at decompressing the biliary tree (McMahon et al, 1995). Percutaneous dilatation alone relieves symptoms in just over half of all cases, whereas transhepatic stenting is effective in up to 85% of cases (Jabłońska and Lampe, 2009). The risk of complication following percutaneous transhepatic cholangiography is about 35% and typically includes haemorrhage, bile leakage and cholangitis, with perforation of the pleura, gall bladder and large bowel occasionally reported.

Figure 5. Endoscopic retrograde cholangiopancreatography showing leak from common bile duct following diathermy injury sustained during laparoscopic cholecystectomy. Note remnant cystic duct stump filling above leakage site. Subsequent stent placement across the site of injury successfully resolved the leak.



Rendezvous procedure

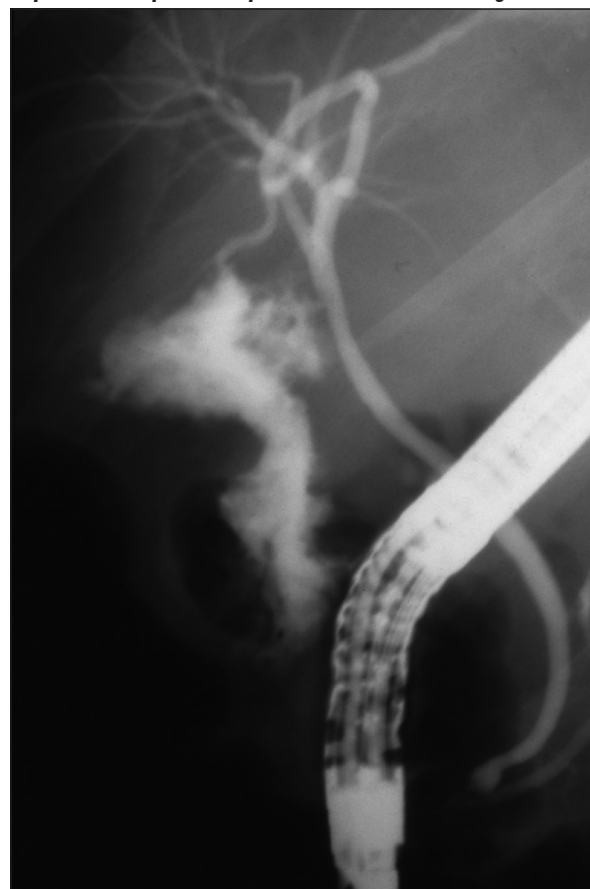
Rendezvous procedures combine percutaneous transhepatic cholangiography and endoscopic retrograde cholangiopancreatography. This is useful when endoscopic stenting is not successful, particularly for strictures close to the hepatic confluence (Nordin et al, 2011). A guidewire can be placed antegradely via percutaneous transhepatic cholangiography to help the endoscopist deploy a biliary prosthesis.

Operative management

Hepaticojejunostomy should be performed immediately after iatrogenic injury (before biliary peritonitis has developed) or after acute inflammation has resolved (up to 6 weeks). Surgery in the interim has increased relative risk and poorer long-term outcomes (Bismuth, 1982; Strasberg et al, 2001); so biliary leakage should be controlled by other means (e.g. stents and percutaneous drains) until fibrosis is established (Stewart and May, 1995; Nordin et al, 2002).

Creation of the biliary anastomosis can be challenging because of the location and size of the residual bile duct (Stewart and May, 1995). The preferred operation for bile duct repair is a Roux-en-Y hepaticojejunostomy. A simple end-to-end repair of a ductal transection is associated with high rates of anastomotic failure or the development of biliary stenosis and future cholestasis (Sawaya et al, 2001;

Figure 6. Endoscopic retrograde cholangiopancreatography showing leak from cystic duct remnant as a result of the ligation clip becoming displaced. Subsequent stent placement resolved the leakage.



Nordin et al, 2002). Dissection and subsequent mobilization of the residual biliary tree may put tension on the anastomosis and jeopardise its arterial supply, causing an ischaemic stricture. The axial blood supply to the supra-duodenal biliary tree (which runs in the 3 and 9 o'clock positions) is also at risk of injury during suture placement and subsequent knot tying to create the anastomosis.

In a hepaticojejunostomy, the jejunal segment is highly mobile with a very good blood supply. The size of the jejunal enterostomy is not critical and is unlikely to narrow after anastomotic formation. A 'parachuting' technique can help create the hepaticojejunostomy: sutures are placed under direct vision before placing the jejunum onto the transected duct and ligating the sutures. The Roux limb prevents reflux of intestinal contents into the liver.

Conclusions

Iatrogenic injuries to the biliary tree are uncommon, but remain a significant cause of morbidity following laparoscopic cholecystectomy. They present diagnostic and therapeutic challenges to the clinician, which vary with how and when the injuries are declared. If an iatrogenic bile duct injury is recognized at the time of surgery, immediate discussion with a hepatopancreatobiliary surgeon can help determine the most appropriate way to proceed. For those diagnosed postoperatively, multimodal management is best, each patient being discussed by a specialist multidisciplinary team. A diagnosis of biliary injury should be considered in postoperative patients presenting with right upper quadrant pain, abdominal abscess or jaundice. **BJHM**

The author would like to thank Professor RCN Williamson for supplying Figures 5 and 6.

Conflict of interest: none.

Attili AF, Carulli N, Roda E et al (1995) Epidemiology of gallstone disease in Italy: prevalence data of the multicentre Italian study on cholelithiasis (M.I.COL.). *Am J Epidemiol* **141**: 158–65

Bajaj JS, Spinelli KS, Dua KS (2006) Postoperative management of noniatrogenic traumatic bile duct injuries: role of endoscopic retrograde cholangiopancreatography. *Surg Endosc* **20**: 974–7

Biffl WL, Moore EE, Offner PJ, Franciose R, Burch JM (2001) Routine intraoperative laparoscopic ultrasonography with selective cholangiography reduces bile duct complications during

laparoscopic cholecystectomy. *J Am Coll Surg* **193**: 272–80

Bismuth H (1982) Postoperative strictures of the bile ducts. In: Blugarth LH, ed. *The Biliary Tract*. V. Churchill Livingstone, New York, NY

Callery MP (2006) Avoiding biliary injury during laparoscopic cholecystectomy: technical considerations. *Surg Endosc* **20**: 1654–8

Carroll BJ, Birth M, Phillips EH (1998) Common bile duct injuries during laparoscopic cholecystectomy that result in litigation. *Surg Endosc* **12**: 310–14

Duncan CB, Riall TS (2012) Evidence-based current surgical practice: calculous gallbladder disease. *J Gastrointest Surg* **16**: 2011–25

Fletcher DR, Hobbs MST, Tan P et al (1999) Complications of cholecystectomy: risks of the laparoscopic approach and protective effects of operative cholangiography: a population-based study. *Ann Surg* **229**: 449–57

Flum DR, Koepsell T, Heagerty P, Sinanan M, Dellinger EP (2001) Common bile duct injury during laparoscopic cholecystectomy and the use of intraoperative cholangiography. *Arch Surg* **136**: 1287–92

Fouch PG, Harian JR, Hoefler M (1993) Endoscopic therapy for patients with a postoperative biliary leak. *Gastrointest Endosc* **39**: 416–21

Gouma DJ, Obertop H (2002) Management of bile duct injuries: treatment and long term results. *Dig Surg* **19**: 117–22

Gupta A, Stuhlfaut JW, Fleming KW, Lucey BC, Soto JA (2004) Blunt trauma of the pancreas and biliary tract: a multimodality imaging approach to diagnosis. *Radiographics* **24**: 1381–95

Gurusamy KS, Davidson BR (2010) Surgical treatment of gallstones. *Gastroenterol Clin N Am* **39**: 229–44

Gurusamy KS, Samraj K, Fusai G, Davidson BR (2008) Early versus delayed laparoscopic cholecystectomy for biliary colic. *Cochrane Database Syst Rev* **8**: CD007196

Hall JG, Pappas TN (2004) Current management of biliary strictures. *J Gastrointest Surg* **8**: 1098–110

Jabłońska B, Lampe P (2009) Iatrogenic bile duct injuries: etiology, diagnosis and management. *World J Gastroenterol* **15**: 4097–104

Joseph M, Phillips MR, Farrell TM, Rupp CC (2012) Single incision laparoscopic cholecystectomy is associated with a higher bile duct injury rate: a review and a word of caution. *Ann Surg* **256**: 1–6

Kaffe AJ, Hourigan L, Luca ND, Byth K, Williams SJ, Bourke MJ (2005) Impact of endoscopic intervention in 100 patients with suspected postcholecystectomy bile leak. *Gastrointest Endosc* **61**: 269–75

Karvonen J, Gullichsen R, Laine S, Salminen P, Grönroos JM (2007) Bile duct injury during laparoscopic cholecystectomy: primary and long term results from a single institution. *Surg Endosc* **21**: 1069–73

McMahon AJ, Fullarton G, Baxter JN, O'Dwyer PJ (1995) Bile duct injury and bile leakage in laparoscopic cholecystectomy. *Br J Surg* **82**: 307–13

Nordin A, Halme L, Mäkilä H, Isoniemi H, Höckerstedt K (2002) Management and outcome of major bile duct injuries after laparoscopic cholecystectomy: from therapeutic endoscopy to liver transplantation. *Liver Transpl* **8**: 1036–43

Nordin A, Grönroos JM, Mäkilä H (2011) Treatment of biliary complications after laparoscopic cholecystectomy. *Scand J Surg* **100**: 42–8

Sahajpal AK, Chow SC, Dixon E, Greig PD, Gallinger S, Wei AC (2010) Bile duct injuries associated with laparoscopic cholecystectomy: timing of repair and long-term outcomes. *Arch Surg* **145**: 757–63

Sawaya DE, Johnson LW, Sittig K, McDonald JC, Zibari GB (2001) Iatrogenic and noniatrogenic extrahepatic biliary tract injuries: a multi-institutional review. *Am Surg* **67**: 473–7

Strasberg SM (2002) Avoidance of biliary injury during laparoscopic cholecystectomy. *J Hepatobiliary Pancreat Surg* **9**: 543–7

Strasberg SM, Hertl M, Soper NJ (1995) An analysis of the problem of biliary injury during laparoscopic cholecystectomy. *J Am Coll Surg* **180**: 101–25

Strasberg SM, Picus DD, Drebin JA (2001) Results of a new strategy for reconstruction of biliary injuries having an isolated right-sided component. *J Gastrointest Surg* **5**: 266–74

Stewart L, May LW (1995) Bile duct injuries during laparoscopic cholecystectomy; factors that influence the results of treatment. *Arch Surg* **130**: 1123–9

Tantia O, Jain M, Khanna S, Sen B (2008) Iatrogenic biliary injury: 13,305 cholecystectomies experienced by a single surgical team over more than 13 years. *Surg Endosc* **22**: 1077–86

Williamson JML (2013) Traumatic injuries to the biliary tree. *Br J Hosp Med* **74**: 128–31

KEY POINTS

- Laparoscopic cholecystectomy is the treatment of choice for uncomplicated, symptomatic gall-stones. The incidence of iatrogenic biliary injury is 0.5%.
- An infundibular technique, with dissection of Calot's triangle to identify the 'critical view of safety', reduces the incidence of iatrogenic injury; routine use of intraoperative cholangiography or ultrasound does not reduce the frequency of injury.
- The difficulty of cholecystectomy is influenced by patient and intraoperative factors.
- Biliary injury can present immediately postoperatively, some days to weeks later and/or insidiously some months later with liver failure. Iatrogenic injury should be considered in any patient who fails to recover after discharge or who presents with vague abdominal symptoms.
- Management of injuries should be discussed with a regional hepatopancreatobiliary unit as the timing and type of further intervention are critical.