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Case Study

Bile duct injury during laparoscopic cholecystectomy - a preventable issue?

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Key Learning Points

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1. Despite extensive training and experience with laparoscopic cholecystectomy, the incidence of bile duct injury remains higher than after open surgery. This is largely due to misidentification of anatomy
2. Obtaining a critical view of safety during LC is recommended to minimise the risk of BDI
3. If CVS cannot be obtained, several strategies are available, such as intra-operative imaging, subtotal cholecystectomy and conversion to an open procedure
4. Identifying injuries during the procedure improves outcomes, as does early referral to a hepatobiliary specialist

Introduction

Laparoscopic cholecystectomies (LCs) are the current gold standard treatment for gallstone disease[1]. However, iatrogenic bile duct injury (IBDI) is a well-documented complication that significantly raises morbidity, mortality, length of hospitalisation, and financial costs[2,3]. With the popularisation of LCs in the 1990s the incidence of IBDIs went up from 0.1-0.5% in open procedures to 3% in LCs[4,5]. With an increasing amount of surgical experience, academic literature, and widespread recognition of the issue, the prevalence of IBDIs in the modern era is falling[6] but they still occur with serious consequences. This report presents a case of an elective LC with iatrogenic common bile duct (CBD) injury that was repaired with a Roux-en-Y hepaticojejunostomy that was later complicated by anastomotic leak and sepsis. It will go on to review the evidence addressing why this happens and how best to prevent it, before briefly touching on management and associated complications. This case report focusses on the IBDI and its complications including fast atrial fibrillation (AF) and sepsis.

Case report

Background

Mr. MW is a 79 year old retired gentleman who was initially admitted for cholecystitis with gallstones. He presented to the ambulatory assessment unit with severe sudden onset epigastric pain of an 8/10 severity. He denied any nausea, vomiting, changes in bowel habit, or melaena. On examination he was apyrexial and normotensive but tachycardic (112 bpm). There was some epigastric tenderness but he was Murphy's negative. Liver function tests were deranged and a computerised tomography (CT) of the abdomen/pelvis revealed a dilated CBD, thickened gallbladder wall, and gallstones, confirming the diagnosis of gallstones and cholecystitis. The episode of epigastric pain settled with analgesia and antibiotics and Mr. MW was discharged 5 days later and booked in for an elective LC.

Socially, Mr. MW lives at home with his wife and two adult sons, and is independent in his activities of daily living. He has a background of coeliac disease with a duodenal stricture that later resolved with a liquid gluten free diet. He has additional diagnoses of hypertension, previous fast AF, gout, and osteoporosis. He was regularly prescribed amlodipine, allopurinol, furosemide, lisinopril, bisoprolol, and omeprazole and has no drug allergies.

Surgical Procedure and Complications

The elective LC was performed several months later. Intraoperatively, dissection of adhesions under the CBD with diathermy resulted in transection of the duct (Stewart-Way Class II injury). The operation was converted to open via a Kocher incision and senior hepatobiliary surgeons were called. The CBD was distally ligated and excised. A Roux-en Y hepaticojejunostomy was performed. The small bowel was divided 30cm distal to the duodenal-jejunal flexure and a 50cm roux limb was measured. 3cm of small bowel was resected due to a jejunal diverticulum at the division site. The jejunum-jejunum anastomosis was formed and a window made through the transverse mesocolon to admit the roux limb. A small enterotomy was made for the hepato-jejunal anastomosis and a Jackson-Pratt (JP) drain placed posteriorly.

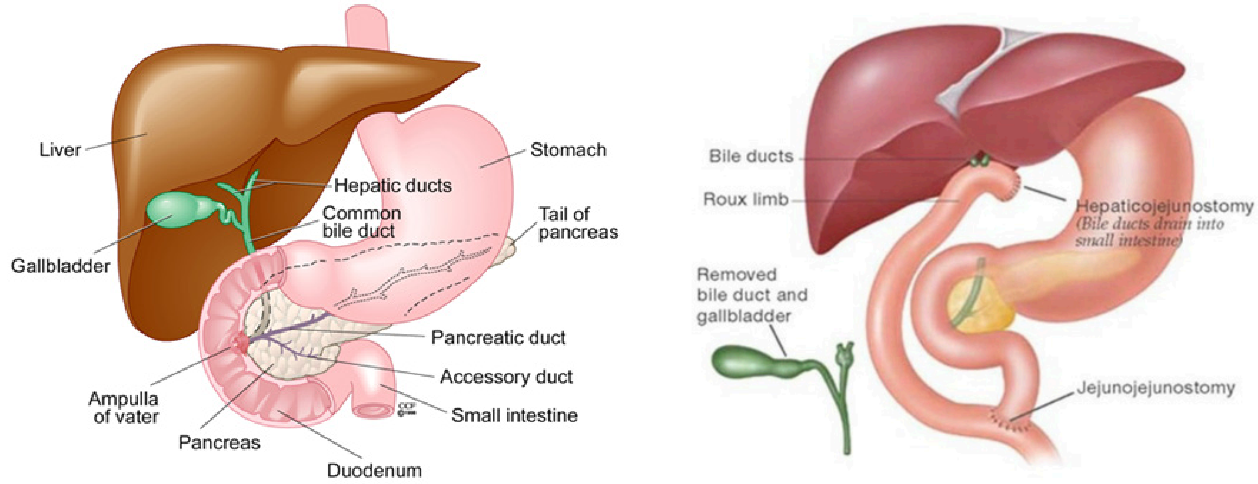

Figure 1. Illustration of normal anatomy (left) and a Roux-en-Y hepaticojejunostomy (right). During the procedure the jejunum is divided and the lower efferent section taken up into the upper right abdomen. The gallbladder is removed and remaining bile ducts are anastomosed to the jejunum, forming the roux limb. The afferent limb, which carries stomach contents, is joined to the roux limb further down, thus allowing bile and stomach contents to mix at this point. (Images found online, unknown source).

Post-Operative Outcome

Mr. MW was admitted to the ward and informed of the intra-operative complications. Allopurinol, amlodipine, furosemide, and lisinopril were stopped on admission. He remained stable for two days but developed sepsis. He became hypotensive and developed fast AF, pyrexia, type 1 respiratory failure, and oliguria. A plain chest radiograph (Figure 2) revealed potential pneumoperitoneum . A stat dose of gentamicin and co-amoxiclav were administered and he was moved to the intensive care unit (ICU) with the working diagnosis of septic shock due to anastomotic leak. A CT of the abdomen/pelvis (Figure 2) confirmed pneumoperitoneum and anastomotic leak at the hepaticojejunostomy. E. coli was grown from bronchoalveolar lavage and JP drain cultures.

Following this rapid deterioration an exploratory laparotomy was performed. The upper right quadrant was contaminated with bile and free air and an obvious anastomotic leak visualised at the hepaticojejunostomy. Mr. MW was deemed too unstable to undergo reconstructive surgery and the leak was managed with abdominal washout and the placement of 3 drains. The pre-existing JP drain was re-sited from the posterior to the anterior hepaticojejunostomy and two addition 30Fr Robinson's drains placed over the right lobe of liver and at the hepaticojejunal defect. He was returned to the ICU intubated and started on piperacillin with tazobactam and parenteral nutrition.

Two days later Mr. MW was extubated and moved back to the wards. He experienced post-ICU hallucinations, which were effectively managed with olanzapine. He was persistently in fast AF and a new diagnosis of aortic stenosis was made, for which he was started on low dose metoprolol. Antibiotics were stopped three days later. A further CT showed continual anastomotic leak with a perihepatic collection of fluid and gas, which was conservatively managed. He was slowly weaned off oxygen, regained mobility, and moved back to enteral nutrition. The drains were removed and he was discharged 30 days after the initial procedure.

Aetiology of IBDIs

The first step to preventing IBDIs, which includes bile duct leaks, lacerations, transection, excision, strictures, and vascular damage, is to understand why they occur. Initially, the increased incidence of IBDIs with laparoscopic vs open surgery was thought to be due to the surgical 'learning curve' – where surgeons were less familiar with the novel technique and therefore more prone to error. However, Archer et al[7] later demonstrated that although there is a learning curve where the rate of IBDIs is higher in a surgeon's first 50 LCs, 30-32.9% of IBDIs occurred after a surgeon had performed >200 LCs. This indicated that inexperience alone was not accountable. Other factors, such as anatomical anomalies, technical errors (ie. misplaced clips or diathermy injury), poor visualisation of anatomy (ie. due to inflammation), and misidentification of the anatomy were identified as potential sources of injury.

Richardson et al[8] first attempted to define these mechanisms of injury in their 1996 Scottish audit (Table 1). 37 IBDIs occurred over a 5 year period, of which 7 were 'classical' injuries, 3 were 'variant classical', 17 were 'tenting' injuries, 5 were 'confluence' injuries, and 5 were 'diathermy' injuries. Contributing factors were only observed in a minority of cases, with severe inflammation being an issue in 7 patients, aberrant anatomy in 4, and poor visualisation in 2. This revealed that the misidentification of anatomy was a major source of IBDIs.

The Stewart-Way system (Table 2), one of many systems for IBDI classification, attempted to further use these causes to group types of IBDI and thus guide surgical management[9]. In their analysis of 252 laparoscopic IBDIs, Class III injuries were the most common (61%), followed by II (22%), IV (10%), and I (7%). Anatomical variation was relevant in 124 cases. This re-iterates that misidentification of the anatomy (class I, III, IV) is the most common cause of IBDI.

Preventing IBDIs

The recognition of the frequency and severity of IBDIs has led to various interventions for their prevention. The value of preoperative risk stratification systems have been debated. Intra-operative interventions, such as the critical view of safety (CVS) and intraoperative imaging including intraoperative cholangiography (IOC), laparoscopic ultrasound (LUS), and near-infrared fluorescent cholangiography (NIFC), have also been proposed with the aim to minimise anatomical misidentification. When

Figure 2. Illustration of no Erect AP radiograph (left) and axial CT scan (right) of Mr. MW's chest and abdomen respectively. The chest radiograph shows likely pneumoperitoneum that was later confirmed by the CT abdomen pelvis. Legend – R: right, L: left, A: anterior, P: posterior, arrows show free air.

clarification of the anatomy is not possible, the value of subtotal cholecystectomies vs total cholecystectomies has been discussed.

Preoperative Risk Stratification

Difficult LC is associated with high rates of complications and conversion to open procedures. It is therefore important to recognise and manage pre-operative factors that affect difficulty. In a systematic review, Hussain et al[10] identified such risk factors including the male sex, increased age, cholecystitis, obesity, liver cirrhosis, and anatomic variation amongst others. The risk posed by cholecystitis can further be stratified using severity grading systems such as the Tokyo Guidelines (TG)[11] or American Association of Surgery and Trauma (AAST)[12], which have directly been shown to correlate to the risk of BDI in LCs[13].

Critical View of Safety[14]

Following the realisation that the misidentification of biliary anatomy was the prominent cause for IBDI, the critical view of safety (CVS)[15] was developed to attempt to minimise these errors by clarifying the anatomy. It is widely accepted to be an effective prevention technique[16]. It is comprised of 3 criteria:

1. The hepatocystic triangle must be cleared of adipose and fibrotic tissues and the CBD and common hepatic duct must not be exposed
2. The lower third of the gallbladder must be separated from the liver bed to expose the cystic plate (the white fibrous tissue where the gallbladder attaches to the liver)
3. Two structures (cystic duct and cystic artery) should be seen entering the gallbladder.

Some evidence has additionally shown that CVS in conjunction with intra-operative doublet photography[17] or other anatomical landmarks, such as using the B-SAFE technique18 (a group of five visual landmarks including the bile duct (B), Rouvier's sulcus (S), hepatic artery (A), umbilical fissure (F), enteric viscera (E)) can improve outcomes.

Intraoperative Imaging

The proposed benefits of intraoperative imaging are two-fold: it can decrease the incidence of IBDIs and allow

Type of Injury	Mechanism of Injury
Classical	CBD mistaken for the cystic duct with CBD clipping and division.
Variant classical	CBD mistaken for proximal cystic duct with clipping. Upper cystic duct identified correctly, clipped, and divided.
Tenting	Lateral traction of gallbladder with tenting of CBD, causing loss of the angle of interception with cystic duct
Confluence	RHD mistaken for cystic duct with clipping and division
Diathermy	Indiscrete use of diathermy in Calot's triangle, causing bile leak or stricture formation

Table 1: Mechanisms of CBD injury adapted from Richardson et al (1996).

Classification	Mechanism of Injury
Class I	CBD mistaken for the cystic duct, error recognised before the CBD is divided
Class II	Lateral damage to common hepatic duct (CHD) from clips or cautery
Class III	CBD mistaken for cystic duct and divided
Class IV	Damage to the right hepatic duct because it's mistaken for the cystic duct or is injured during dissection

Table 2: The Stewart-Way Classification

for the intraoperative identification and thus management of IBDIs if they do occur. There is evidence to support both IOC and LUS as modalities to image and identify bile duct anatomy during LC, thus reducing IBDIs[14]. Alvarez et al[19] routinely performed IOCs in 11423 LCs and found that IOC was associated with a lower incidence of IBDIs. They also concluded it had a 78% sensitivity and 100% specificity for recognising IBDIs, allowing all injuries identified to be repaired in the same procedure thus reducing post-operative complications and the need for further surgery. Machi et al[20] found similar success with LUS, analysing 1381 LCs with LUS and finding that it clarified the underlying anatomy in 98% of cases and reduced rates of IBDI. However the literature is not conclusive, with some studies finding no effect and several drawbacks including increased operating time[21].

NIFC has more recently been applied for extrahepatic biliary imaging during LC. A randomised single-blind trial recently compared NIFC vs while light alone pre- and post-dissection during a LC[22]. They found that NIFC was superior at detecting biliary structures at both time points. However there is still limited evidence for the value of NIFC vs IOC in IBDI detection and further trials are required.

Laparoscopic Subtotal Cholecystectomy (LSC)

Although outcomes are often poorer with LSC than the gold standard laparoscopic total cholecystectomy[23], it is widely accepted that in difficult procedures where the biliary anatomy is difficult to identify LSC is a safe alternative[24]. LSC, which leaves the posterior wall of the gallbladder attached to the liver, avoids accidental injury to the structures of Calot's triangle when they cannot be reliably visualised. Typical indications include severe cholecystitis, cholelithiasis, empyema, or perforated gallbladder[25].

2020 Multi-Society Practice Guideline

In recognition of the prevalence of IBDIs in LCs, a multi-society consensus conference was held to establish clear guidelines for IBDI prevention and safe LC practice. The evidence for 18 key questions, including those discussed above, was reviewed and recommendations made using the GRADE methodology. The key recommendations for IBDI prevention are outlined below:

1. CVS should be used for anatomic identification in LC
2. If CVS cannot be identified, LSC is recommended over total cholecystectomy
3. IOC or LUS should be used in patients with acute cholecystitis, a history of cholecystitis, where there is uncertainty regarding the biliary anatomy, or when IBDI is suspected
4. NIFC may be used as an adjunct to white light to identify biliary anatomy but should not be relied on
5. TG or AAST classification should be used to grade the severity of cholecystitis pre-LC
6. Any factors that may make a LC more difficult should be identified during operative planning and intraoperative decision-making.

Whilst the benefit of these guidelines is yet to be observed, there is evidence suggesting that further work is need to implement these recommendations. For example, in 2021 Christou et al[26] found that even when IOC was used perioperatively, interpretation by surgeons was poor with abnormal results declared normal and normal results declared abnormal. This demonstrates that simply implementing the guidelines is not enough and further surgeon training on interpreting findings and using them to guide management is essential.

Management of IBDI

In this case study, the IBDI occurred within a tertiary healthcare setting, was recognised immediately, and the injury repaired with the gold-standard Roux-en-Y hepaticojejunostomy by an experienced multi-disciplinary team (MDT). All of these factors are independently associated with fewer post-operative complications[27]. However, shortly after the reconstruction an anatomic leak at the hepaticojejunostomy complicated his recovery, rendering him septic and in need of a second exploratory and washout surgery. Anastomotic leak after hepaticojejunostomy is well-documented and in a study of 1033 patients occurred in 2.3%[28]. Additionally, Ismael et al[29] analysed 293 IBDI patients and who underwent a hepaticojejunostomy and found that 26.3% developed a postoperative complication. The most common of these were superficial wound infection (10.6%), sepsis (6.5%), and return to theatre (4.8%), two of which were experienced by Mr. MW.

Perspectives and Conclusions

In this case, an elective LC was performed at a tertiary centre by an experienced surgeon with no pre-operative complicating factors. However a CBD injury still occurred. The most common reason for this is anatomical misidentification, which may have been helped by preventative measures such as the CVS or intraoperative imaging. The injury was identified intra-operatively and reconstruction performed by a MDT, which the literature has shown produces the most favourable outcomes. However, anastomotic leak, sepsis, and a return to theatre still occurred. This arguably demonstrates that the elimination of IBDI is still some way away and further research on safe LC protocol, the management of IBDIs, and the complications of biliary reconstruction is required.

Conflicts of interest

None.

Funding

None.

Consent

The patient has consented to the publication of this case study.

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