Original Articles

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SURGICAL ENDOSCOPY and Other Interventional Techniques

Bile duct injuries during laparoscopic cholecystectomy: primary and long-term results from a single institution

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Abstract
Background: Iatrogenic bile duct injury carries high morbidity. After the introduction of laparoscopic cholecystectomy the incidence of these injuries has at least doubled, and even after the learning curve, the incidence has plateaued at the level of 0.5%.
Methods: A total of 32 patients sustained biliary tract injuries of the 3736 laparoscopic cholecystectomies performed in and around Turku University Central Hospital between January 1995 and April 2002. The data concerning primary treatment and long-term results were collected and analyzed retrospectively.
Results: The overall incidence for bile duct injuries, including all the minor injuries (cystic duct leaks and bile duct strictures), was 0.86%; for major injuries alone the incidence was 0.38%. Nineteen percent of the injuries were detected intraoperatively. All the cystic duct leaks were treated endoscopically with a 90% success rate. Of the bile duct strictures 88% were treated successfully with endoscopic techniques. Ninety-three percent of the major injuries, including tangential lesions of common bile duct and total transections, were treated operatively. The operation of choice was either hepaticojejunostomy or cholangiojejunostomy in 69% of the cases; the rest were treated with simple suturing over a T-tube or an endoscopically placed stent. The long-term results, with a median follow-up period of 7.5 years, are good in 79% of the operated patients and in 84% of the whole study population. Mortality rate was 3% and acute or chronic cholangitis was seen in 13% of the patients during follow-up.
Conclusion: Most of the minor bile duct injuries, including cystic duct leaks and bile duct strictures, are well treatable with endoscopic techniques, whereas most of the major injuries require operative treatment, which at optimal circumstances gives good results.

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Key words: Laparoscopic cholecystectomy — Iatrogenic bile duct injury — Endoscopic retrograde cholangiopancreatography — Amsterdam criteria

Since its introduction in late 1980s, laparoscopic cholecystectomy has rapidly replaced open cholecystectomy as a treatment of choice for symptomatic gallstone disease and acute cholecystitis. Laparoscopy provides many benefits for the patient, including shorter hospital stay, earlier return to normal activities, improved cosmetic results, and less postoperative pain.

Iatrogenic bile duct injury (BDI) is a severe complication that may have a great impact on the patient's physical and mental quality of life [1]. Although BDIs may occur in all kinds of upper abdominal operations, the vast majority take place during biliary surgery. Earlier, in the era of open cholecystectomy, the incidence of BDIs remained at 0.1%–0.2% [2], but after the introduction of the laparoscopic method the rate of BDIs has at least doubled. According to early reports the rate of iatrogenic BDIs sustained during laparoscopic cholecystectomy was as high as 0.8%–1.4% [3–5], and even after the learning curve, the rate has remained at 0.5%–0.6% [6, 7].

The clinical practice in Finland is that the diagnostics and treatment of all suspected or confirmed BDIs are centralized in central hospitals like ours. The purpose of the present study was to analyze the occurrence and treatment of BDIs sustained during laparoscopic cholecystectomy in and around Turku University Central Hospital, with special attention paid to the long-term results.

Patients and methods

Turku University Central Hospital is a 950-bed teaching hospital serving an area of more than 450,000 inhabitants in southwestern Finland. The number of people living in our area of responsibility is

Table 1. Amsterdam classification of severity of bile duct injury

Type	Indication
A	Leakage from cystic duct or peripheral radicals
B	Major bile duct injury with leakage
C	Bile duct stricture without leakage
D	Complete transection or excision of common bile duct

the third largest in Finland, and we serve one tenth of all Finns. Laparoscopic cholecystectomies are performed also in six district hospitals in the vicinity, but all the patients with suspected BDIs are referred to Turku University Central Hospital for diagnosis and treatment. Our hospital is the only hospital in the area with magnetic resonance cholangiopancreatography (MRCP) and endoscopic retrograde cholangiopancreatography (ERCP) facilities. Nowadays more than 400 ERCPs are done every year. Recently, we described our indications, techniques, and results of ERCP procedures performed from 1997 to 2003 [8]. A total of 3736 laparoscopic cholecystectomies were performed in and around Turku University Central Hospital between January 1995 and April 2002. Most of the patients underwent elective laparoscopic cholecystectomy for uncomplicated gallstone disease. The treatment strategy for patients with suspected bile duct stones in our area includes preoperative MRCP and/or ERCP before laparoscopic cholecystectomy, and, thus, intraoperative cholangiographies are seldom done. The training status of the surgeons varied from beginner to very experienced laparoscopic surgeon.

In this retrospective study, we included and examined all the patients with BDI after laparoscopic cholecystectomy. Two patients with a diagnosis of gallbladder and bile duct malignancy, respectively, were excluded and the eight BDIs after conventional open cholecystectomy also were excluded. Intraoperative, perioperative, and cumulative postoperative follow-up data for patients with BDI were collected from electronic archives of the hospital district of southwestern Finland in May 2006 and all patients were also interviewed by phone by one of the authors (JK). Data on the occurrence, definitive treatment, and long-term results of BDIs were collected for every patient. The median follow-up time was 7.5 years (range = 4–11 years).

The type of the BDI was assessed by the findings in ERCP and/or at laparotomy. Patients were then divided into subgroups according to the severity of the BDIs. For this purpose we used Amsterdam criteria [9] (Table 1). Type A and C lesions were considered mild and type B and D lesions severe.

Results

Patients and cholecystectomy

The overall incidence for BDI during laparoscopic cholecystectomy was 0.86% and the incidence for major BDI (Amsterdam types B and D lesions) was 0.38%. The group of patients with BDI (n = 32) included 25 females and 7 males. The median age of the patients at the time of laparoscopic cholecystectomy was 44 (range = 17–70) years. Four patients (12%) were operated on because of acute cholecystitis. One patient (3%) waiting for renal transplantation was operated on because of asymptomatic gallstones. The remaining 27 patients (85%) underwent elective operations for biliary colic, of which nine patients had chronic cholecystitis. Twenty-one operations (66%) were performed by an experienced laparoscopic surgeon and the remaining 11 operations (34%) were performed by a resident in surgery with or without a senior surgeon. Eleven patients (34%) underwent laparoscopic cholecystectomy at our university hospital, whereas 20 patients (63%) were referred from the six district hospitals and one (3%) from a private hospital. The median diagnostic delay was 10 (range = 0–181) days. Ten of the operations (31%) were reported as uncomplicated, whereas in 22 cases (69%) some kind of technical problem was encountered (Table 2). Six operations (19%) were converted to an open procedure during the same anesthesia because of technical problems or a suspicion of a BDI; in all other cases ERCP was done before the definitive operation. Fifteen of 32 patients (47%) were treated endoscopically only, 1 (3%) was treated by an interventional radiologist and 16 patients (50%) were operated on. One patient (3%) died 25 days from sepsis after the laparoscopic cholecystectomy. He had renal failure due to chronic pyelonephritis and was waiting for a renal transplant. In the follow-up, one patient (3%) had suffered from chronic cholangitis and three patients (9%) from attacks of acute cholangitis. Individual patient data are shown in Table 3.

Table 2. Technical problems during laparoscopic cholecystectomy reported in 22 of 32 patients with bile duct injuries[a]

Technical problem	Number encountered
Chronic cholecystitis	9
Obesity	5
Acute cholecystitis	4
Bleeding	4
Short cystic duct	4
Adhesions	3
Rupture of cystic duct	2

[a] Some patients had multiple problems

Management of type A injuries

All patients (10/10) with type A lesions were treated endoscopically. Eight patients underwent endoscopic sphincterotomy and biliary stenting (10 Fr), one patient had endoscopic sphincterotomy and stone extraction, and one patient had endoscopic sphincterotomy only. One patient died and all the others recovered uneventfully.

Management of type B injuries

Of the patients with type B lesions, one was treated by an interventional radiologist with percutaneous transhepatic cholangiography (PTC) and stenting; the others (four of five) were operated on. Two laparoscopic operations were converted immediately, whereas two patients were operated on later. Three patients were treated with suturing over a t-tube or endoscopic stent. One patient underwent hepaticojejunostomy. In the follow-up, one patient had acute pancreatitis once and another patient underwent endoscopic stricture dilatation twice. The remaining three patients recovered uneventfully.

Management of type C injuries

Of the cases with type C lesions, one laparoscopic cholecystectomy was converted to an open procedure with suturing. In the follow-up five years later, this patient

Table 3. Demographic data, classification of the bile duct injury, treatment, follow-up time, and long-term results of the patients with iatrogenic bile duct injury during laparoscopic cholecystectomy

No.	Age	Gender	Lesion type	Treatment	Follow-up (months)	Long-term results
1	49	m	A	ERC + EST + stent	96	uneventful
2	44	m	A	ERC + EST + stent	57	uneventful
3	79	f	A	ERC + EST + stent	55	uneventful
4	60	f	A	ERC + EST	99	uneventful
5	35	f	A	ERC + EST + stent	54	uneventful
6	39	f	A	ERC + EST + stent	82	uneventful
7	24	f	A	ERC + EST + stone extraction	65	uneventful
8	31	f	A	ERC + EST + stent	55	uneventful
9	46	m	A	ERC + EST + stent	89	uneventful
10	68	m	A	ERC + EST + stent	68	death
11	42	f	B	Conversion, suturing + T-tube	55	dilatation x 2
12	30	f	B	ERC + stent, laparotomy + suturing	52	uneventful
13	28	f	B	Conversion, ERC + stent	136	uneventful
14	36	f	B	HJS + T-tube	114	pancreatitis x 1
15	40	m	B	PTC + stent	127	uneventful
16	56	f	C	Conversion + suturing	111	ERC + stone extraction 5 years later
17	61	f	C	ERC – relative stricture	109	pancreatitis x 3
18	70	f	C	ERC + dilatation + stent	131	dilatation x 5
19	53	f	C	ERC + dilatation + stent	91	dilatation x 3
20	17	f	C	ERC – relative stricture/anatomical variation	91	uneventful
21	46	f	C	Laparotomy + ligation of accessory duct	110	dilatation x 4
22	31	f	C	ERC + dilatation + stent	97	dilatation x 3
23	28	f	C	HJS	100	chronic cholangitis
24	63	f	D	CJS	101	uneventful
25	66	m	D	Conversion + HJS	55	uneventful
26	33	f	D	Conversion + suturing + T-tube	49	dilatation x 5
27	52	f	D	Conversion + HJS	80	uneventful
28	62	m	D	HJS	100	adhesiolysis 1 year later
29	44	f	D	Laparotomy x 3 > > referral to HUCH, CJS	55	cholangitis x 1, ventral hernia, disability pension
30	43	f	D	HJS	110	cholangitis x 2
31	40	f	D	HJS	59	cholangitis x 6
32	67	f	D	HJS	77	uneventful

ERC = endoscopic retrograde cholangiography; EST = endoscopic sphincterotomy; PTC = percutaneous transhepatic cholangiography; HJS = hepaticojejunostomy; CJS = cholangiojejunostomy; HUCH = Helsinki University Central Hospital

presented with relative bile duct stricture and stones, which were successfully removed endoscopically. Another patient underwent laparotomy one week after laparoscopic cholecystectomy and an accessory bile duct was ligated. Afterward, her liver function tests fluctuated so endoscopic stricture dilatation was performed four times. The third patient had subtotal blockage in the hilar area in ERCP, presumably because of an injury caused by diathermy. Hepaticojejunostomy was done three months after the initial operation. This patient suffered from chronic cholangitis caused by anastomotic stricture that had been percutaneously dilated several times. Endoscopic measures were sufficient in the treatment of seven of eight patients with type C lesions. One of these patients suffered from an attack of acute pancreatitis three times, and four have undergone endoscopic dilatations after which they have been asymptomatic. The remaining patient with a type C lesion recovered primarily uneventfully. However, ERCP was done to one patient six years later because of a mild fluctuation in liver function tests. A slight segmental narrowing of the common hepatic duct was found. However, there were no signs of obstruction and a dilatation was considered unnecessary. The patient has had no symptoms thereafter.

Management of type D injuries

Of the nine patients with type D lesions, all were naturally operated on. Six patients underwent hepaticojejunostomy, two patients had a cholangiojejunostomy, and one patient had a hepaticocholedochostomy and t-drainage. Four of these nine patients recovered uneventfully. One patient developed intestinal obstruction one year after the primary operation and was treated at laparotomy by adhesiolysis. The patient with hepaticocholedochostomy developed an anastomotic stricture, which was treated successfully with repeated (five) endoscopic dilatations. Two patients have had recurrent episodes of cholangitis and both suffer from constant biliary symptoms. One patient was operated on three times in the early phase. Hepaticojejunostomy was performed twice with unsuccessful results, and in the third operation hepatic ducts and the abdominal cavity were only drained. After the third operation the patient was referred to Helsinki University Central Hospital, which is the only transplantation and liver surgery unit in Finland. Cholangiojejunostomy was done two months after the initial operation. Afterward, the patient underwent hernioplasty because of massive ventral hernia. She

has also had cholangitis once and other biliary symptoms occasionally.

Discussion

In the present series of 32 patients with BDIs, all the Amsterdam A lesions were treated with endoscopic techniques. Similarly, in Amsterdam C lesions seven of eight patients were treated successfully with endoscopic measures only, although two had undergone conversion to an open procedure because of other reasons during the primary operation or shortly after. All the type D lesions naturally required operative treatment. Similarly, in type B lesions, four of five patients had to be operated on. Primary and long-term results have been good with a few exceptions. One patient with severe chronic pyelonephritis developed biliary peritonitis and sepsis and died 25 days after the primary operation. Another patient with a presumed diathermy lesion in the hilar area developed anastomotic stricture after hepaticojejunostomy and suffered from chronic cholangitis thereafter. In addition, three patients had constant biliary symptoms and a few episodes of cholangitis. The vast majority of patients (84%) recovered well, even though often after repeated endoscopic procedures.

Severe BDI is a rare but morbid complication of laparoscopic cholecystectomy. The classic type D BDI occurs during laparoscopic cholecystectomy when the cystic duct and the common bile duct are aligned by traction on the gallbladder, and the common bile duct is mistakenly identified as the cystic duct and clipped and divided. Many different conditions have been associated with increased risk of BDI, including acute cholecystitis, acute pancreatitis, cholangitis, scarring of Calot's triangle, intraoperative bleeding, anatomical variations, female gender, and lack of surgical skills [10–12]. Other factors involved are uncontrolled clip placement and liberal use of diathermy. In the current series only 12% of BDIs occurred in acute cases. The most common problem encountered was scarring of Calot's triangle due to chronic cholecystitis in one- third of the cases; technical problems were encountered in over two thirds of the cases. The results of the present study support earlier views in this respect (see Table 2). We find that the surgical technique is the most important factor in preventing BDIs. It does not matter which technique is used, i.e., the French (surgeon between the legs of patient) or the U.S. technique (surgeon to the left of patient), because neither of them, if correctly used, is associated with increased risk for BDI [6] Most problems can be avoided by following Hunter's principles, i.e., use 30° laparoscope, use combination retraction involving meticulous dissection close to gallbladder-cystic duct junction, and stay out of Calot's triangle and common bile duct area [13, 14].

The role of intraoperative cholangiography (IOC) in avoiding BDIs has been discussed since its introduction [15]. Some authors recommend routine use of IOC; they found that about one third of the BDIs could be prevented using IOC [3, 16, 17]. However, there is much controversy in the literature on the routine use of IOC. Olsen reported a series of 177 BDIs where only 2 of the 32 IOCs performed were interpreted correctly [18]. Carroll et al. [16] reported a series of 46 BDIs with 16 IOCs of which 11 were interpreted incorrectly, and Thomson et al. [19] reported 27 BDIs where 8 of the 10 IOCs were misinterpreted. Moreover, BDI may even originate at IOC by catheter manipulation [19, 20]. Furthermore, IOC does not show the lesions induced after cholangiography. Although the role of IOC in preventing BDIs remains unclear, IOC is an important tool in detection of injuries. Therefore, particularly in cases with anatomic uncertainty, it should be used liberally [21].

The definitive therapy for BDI depends on the type of lesion and the timing of its recognition. The rate for intraoperative detection of BDI was 19% in the present study, whose percentage is well in accordance with earlier reports [9, 22].

If an Amsterdam B or D lesion is detected during the primary operation and the surgeon has enough experience in biliary surgery, hepaticojejunostomy or primary repair over T-tube should be done. In case of limited surgical competence, only drainage tubes should be placed and the patient should be referred to a tertiary center and reoperated on by an experienced hepatobiliary surgeon. The role of primary repair over a T-tube has been debated because the anastomosis tends to stricture over time. According to the current results, we find that the stricture, if encountered, is usually treatable by endoscopic dilatations, and if endoscopic measures fail to overcome the problem, hepaticojejunostomy can be performed afterward.

If the lesion is not detected during the primary operation, explorative laparotomy should be avoided before further classification and possible therapy at ERCP. In case of total transection, PTC or MRCP gives additional information on the proximal part of the biliary tree. In most Amsterdam type A and C lesions, ERCP and endoscopic measures are not only diagnostic but also therapeutic. Particularly in type A lesions, endoscopic treatment has proven to be very effective and success rates between 89% and 93% have been published [1, 9]. Our results are in accordance with previous findings in this respect. In biliary strictures (type C lesions), earlier results of endoscopic treatment have been somewhat disappointing with a success rate of 38% [9]. In our series five of eight strictures (63%) were treated successfully endoscopically; two of eight strictures (25%) needed no further measures and only one patient (12%) required hepaticojejunostomy. Therefore, we find that the primary treatment of type C lesions should be endoscopic.

In type D lesions Roux-en-Y hepaticojejunostomy is generally considered the operation of choice [1, 23]. In our series one patient with a type D lesion had a suturing over a T-tube; all the others underwent hepaticojejunostomy. We find that in type D lesions that are complicated by severe biliary peritonitis, a biliary drainage procedure should be considered and hepaticojejunostomy should be performed by an experienced hepatobiliary surgeon only after biliary peritonitis has settled down.

Of the severe injuries in our study, 93% were eventually operated on with good long-term results in 79%. In the whole study population, long-term results were good in 84%. Our results are consistent with those of earlier studies in which successful recovery rates between 76% and 87% were reported [22, 24]. At tertiary referral centers specializing in bile duct surgery, successful outcome after surgical therapy is between 84% and 98% [25, 26]. In case of BDI the optimal treatment requires a multidisciplinary team, including interventional radiologist, ERCP facilities, and an experienced hepatobiliary surgeon. In the most complicated cases early referral to a tertiary center is crucial.

In conclusion, our organization, serving less than half a million people and involving one referral hospital, seems to work satisfactorily with respect to the treatment of BDIs. Primary and long-term results in a median follow-up of 7.5 years are at an internationally acceptable level.

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