Surgical management of post-cholecystectomy bile duct injuries: referral patterns and factors influencing early and long-term outcome

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Abstract

Background: Cholecystectomy-related bile duct injuries (BDI) remain a cause of significant morbidity and debate concerning optimal management is ongoing. **Methods:** We reviewed our experience with surgical management of BDI to assess patterns of referral along with postoperative and long-term outcomes. **Results:** In the period September 1996 – August 2013, 35 patients were operated in our tertiary care center for a Bismuth-Strasberg grade > A BDI after a cholecystectomy performed elsewhere. Injury grade distribution was as follows: D, n=3; E1, n=4; E2, n=15; E3, n=5; E4, n=5; E5, n=3. Four patients (11.4%) had an associated vascular injury (arterial, n=2; portal, n=1; both, n=1). Treatment was direct repair + Kehr drain placement (n=1), hepatico-jejunostomy (n=28), hepatico-jejunostomy + hepatic resection (n=5) and liver transplantation (n=1). There was one postoperative death (2.8%) due to hepatic failure after liver resection; severe (Dindo-Clavien grade ≥ 3b) complications were observed in 12 (34.3%) patients. Sepsis at referral (OR 17.33, p=0.007) and laparotomy prior to definitive repair (OR 14, p=0.04) were the factors associated with severe complications. Median follow-up was 81 (range 12–182) months; two patients were lost to follow-up. Treatment failure (defined as need for reoperation or interventional radiology procedure during follow-up) was observed in 7/32 (21.9%) patients. No association between baseline variables and treatment failure was observed. **Conclusions:** Post-cholecystectomy BDI represent a heterogeneous entity. The whole armamentarium of the hepato-biliary surgeon is required to achieve proper management. Patients referred with sepsis and requiring laparotomy prior to definitive repair are more prone to develop severe complications.

Keywords: cholecystectomy, bile duct injury, laparoscopy, injury progression, outcome.

Introduction

Post-cholecystectomy bile duct injuries (BDI) represent a well-known cause of early and long-term morbidity and mortality and are associated with reduced health-associated quality of life and frequent legal litigation [1 - 3]. Furthermore, most patients suffering from BDI are in their working age and underwent cholecystectomy for a benign pathology. The introduction of laparoscopic cholecystectomy has been associated with an increase in BDI incidence rate from 0.3% to 0.5-0.8% [4, 5]. A large body of literature has been dedicated to study BDIs types and the technical principles to prevent them [6]. Nevertheless, BDI do and will occur, as even experienced hepato-biliary surgeons are exposed to cause them [7]. Early experience with other minimally invasive techniques, like natural orifices transluminal endoscopic surgery and single-port laparoscopic surgery, has shown that this figure could further increase [8, 9].

As BDI management is frequently challenging and inappropriate therapy can possibly complicate or jeopardize results of further treatment, many Authors have plead for an early referral of BDI patients to tertiary care centers, where all necessary therapeutic means and expertise are available [10 - 12].

Unfortunately, even nowadays BDI patients are sometimes referred to specialized hepatobiliary units late and their management could still be improved. Thus, we reviewed our experience with surgically treated BDI referred to our institution to describe injury evolution and patterns of referral, and to identify factors associated with postoperative morbidity and long-term outcome.

Patients and methods

Patient selection and data collection

Patients referred to our tertiary care center for surgical management of a Bismuth-Strasberg [13] grade > A BDI during the period September 1996 – August 2013 were identified through ICD-9-CM codes 5762 (bile duct stricture), 5763 and 5764 (bile duct fistula). Medical charts were obtained to confirm the relationship of BDI with previous cholecystectomy, excluding patients in whom injury was not deemed unequivocally related to the index operation. Collected data included details concerning index cholecystectomy, injury grade, pre-referral presentation and management, patient comorbidities, repair technique, postoperative

course and long-term results. Reports of previous operations, radiological exams, endoscopic and interventional radiology procedures were thoroughly reviewed. Whenever possible, original cholangiograms were directly evaluated.

Patient management

After referral, the anatomy of BDI was defined by thorough analysis of previous cholangiograms; in doubtful cases patients were studied by endoscopic retrograde cholangiopancreatography (ERCP), percutaneous transhepatic cholangiography (PTC) or magnetic resonance cholangiopancreatography. Patients presenting with biliary peritonitis or abdominal bile collections were managed by percutaneous drainage, percutaneous transhepatic drainage (PTD) or laparotomy, as indicated, deferring definitive BDI repair after the resolution of sepsis. Pre-operative positioning of a PTD was considered in difficult cases to facilitate intra-operative localization of injured bile ducts. Intra-operatively, the choice of stenting the biliary anastomosis was based on the caliber, number and viability of the bile ducts proximal to the anastomosis. When already present, the PTD was replaced with a soft pig-tail drain, positioned across the anastomosis. If a PTD was not already in place and was deemed necessary, it was positioned intra-operatively as previously described [14]. In some cases a transjejunal drain was preferred, positioning the tip of the drain into the bile duct and pulling it out of the jejunum 20 cm downstream through a serosal tunnel on the antimesenteric border, similarly to a Witzel procedure [15]. In the absence of complications, stents were removed three weeks after the operation, after having verified the patency of biliary anastomosis and the absence of leaks by cholangiography. Patients were followed-up by ultrasonography and liver function tests at six months and one year after the operation, and yearly thereafter.

Classifications

Bile duct injuries were classified according to the Bismuth-Strasberg classification [13]. Injury progression was defined as an increase in the severity grade or as the development of cirrhosis. Dindo-Clavien classification was used for postoperative complications, defining grade ≥ 3b complications as severe [16]. Standard definition was used for sepsis [17]. Long-term treatment failure was defined as the need for further surgical or interventional radiology procedure. Outcome was defined fair when an asymptomatic stricture

was diagnosed at imaging exams or in case of a mild, clinically silent alteration of liver function tests. In the remaining patients the outcome was defined as good.

Study endpoints

Study endpoints were the rate of severe postoperative complications and of long-term treatment failure.

Statistical analysis

Data are presented as median (interquartile range) or number (percentage). Fisher's exact and Mann-Whitney tests were used to compare categorical and continuous variables, respectively. Factors associated with severe postoperative complications and treatment failure were identified by logistic regression. All analyses were carried out using R statistical software package version 3.1.2.

Results

During the study period, a total of 35 patients with grade > A BDI were managed. In 19 (54.3%) patients the indication for surgical repair was a bile duct stricture, whereas 16 (45.7%) patients presented with a fistula (Table 1). There were no differences among study groups, except for a non-significant trend towards acute cholecystitis as the indication for initial cholecystectomy in the stricture group ($p = 0.06$) and for the fact that sepsis at referral was observed only in patients in the fistula group ($p = 0.001$). Most patients (n = 26, 74.3%) were managed with ERCP +/- stenting before referral. In 7 (20%) patients an attempt at repair was made during the initial cholecystectomy, whereas in further 7 (20%) an operative repair was attempted afterwards. At referral, biliary bifurcation (grade ≥ E3) was involved in 13 (37.1%) patients, with complete separation of right and left systems in 8 (22.8%). A vasculo-biliary injury was observed in 4 (11.4%) patients.

The comparison between the injuries as initially described and at the time of repair showed that 15 (42.8%) patients experienced an injury progression towards a higher grade (Figure 1 and Table 2). This was more frequently observed in patients presenting with a stricture (63.1% versus 18.7%, $p = 0.006$). Patients in the stricture group presented an injury progression mainly in the form of a more proximal involvement of the bile duct (n = 10, 52.6%) or of a hepatic fibrosis (n = 2, 10.5%) or cirrhosis (n = 3, 15.8%) due to chronic cholangitis, associated with prolonged (> 3 months) stenting in 7 (36.8%) cases. Patients in the fistula group

presented an injury progression most frequently due to bile duct necrosis (n = 2, 12.5%). In one patient (6.2%) presenting with biliary peritonitis, necrosis of the right bile duct was consequent to the injury of the right branch of hepatic artery during PTD positioning.

Patients with biliary leak were referred earlier after injury (44 versus 577 days, $p < 0.001$) and required more frequently drainage of bile collections immediately after referral (37.5% versus 0%, $p = 0.004$) (Table 3). Three patients underwent laparotomy prior to definitive repair. In two cases the indication was the control of abdominal bile collections and sepsis. In the third patient, presenting with a late stricture, laparotomy was indicated to directly assess injury anatomy and repair feasibility. This patient had a history of subclinical hepatitis C-related cirrhosis and presented with a grade E4 stricture that would have ideally required a right hepatectomy and a hepaticojejunostomy on the left bile duct. Due to subjacent cirrhosis, the risk of posthepatectomy liver failure was deemed unacceptable and the patient was scheduled for liver transplantation.

Treatment consisted in most cases in a single (n = 30, 85.7%) or double-barrel (n = 3, 8.6%) hepatico-jejunostomy on a Roux-n-Y jejunal loop; patients referred for biliary fistula were more prone to require a double biliary anastomosis ($p = 0.01$). Stenting of the biliary anastomosis using a transhepatic, transjejunal or Kehr drain was performed in 20 (57.1%), 4 (11.4%) and 1 (2.8%) patients, respectively. A major hepatic resection was carried out in 6 (17.1%) patients, including the patient who required liver transplantation. At logistic regression, factors associated with hepatic resection were grade $\geq$ E3 (OR: 13.12, $p = 0.027$) and grade $\geq$ E4 injury (OR: 43.3, $p = 0.002$).

One patient (2.8%) suffering from a vasculo-biliary injury involving the right hepatic duct and the homolateral branch of hepatic artery died in the postoperative period due to posthepatectomy liver failure after right hepatectomy and hepatico-jejunostomy on the left bile duct (Table 4). A biliary leak was observed in 4 (11.4%) patients, one case being due to a leakage from the entry point of the PTD into the liver parenchyma. Although frequent (n = 9, 25.7%), PTD-related complications were generally low-grade and easily managed by drain replacement or repositioning. Severe complications rate was 34.3%. At logistic regression, the variables associated with severe morbidity were sepsis at referral (OR = 17.3, $p = 0.007$) and laparotomy after referral prior to definitive repair (OR = 14, $p = 0.04$) (Table 5).

Median follow-up was 81 (12 – 182) months. Excluding the patient who died in the postoperative period and two patients who were lost to follow-up, a good long-term outcome was achieved after the first treatment in 22 (68.7%) patients. Three (17.6%) patients experienced a fair outcome due to chronic alteration of liver function tests (n = 1) or evidence of a clinically indolent anastomosis sub-stenosis (n = 2). Treatment failure was observed in 7 (21.9%) patients, with no significant differences among the study groups. Median time to failure was 48 (range 18 – 86) months (Figure 2). However, all seven patients experiencing failure were successfully managed with antibiotic therapy and percutaneous balloon dilatation, finally achieving a fair result. Logistic regression did not identify a significant association of treatment failure with any baseline and operative variables.

Discussion

The main finding of the present study is that the progression of BDI severity from the moment of injury to that of referral still occurs in nearly half of the patients, and is more frequent in patients presenting with a stricture. On the other side, patients having a biliary leak are more frequently septic at referral and pose a greater technical challenge, as suggested by the higher number of required anastomoses. Sepsis at referral and need for laparotomy before surgical repair are the factors significantly associated with the development of severe complications.

The analysis of referral patterns and subsequent surgical treatment confirms that BDI management requires the most comprehensive array of surgical techniques in the armamentarium of the hepatobiliary surgeon, including complex biliary reconstructions, major hepatic resections and, in selected cases, liver transplantation [18]. Furthermore, surgery needs to be properly integrated with operative endoscopy and interventional radiology. The availability of skilled interventional radiologists capable of performing difficult percutaneous drainages and dealing with non-dilated biliary systems is fundamental [19 - 22]. In our series only two patients required laparotomy to control abdominal sepsis prior to definitive repair, whereas all the others were successfully managed by percutaneous drainage and transhepatic biliary drainage. Pre-operative positioning of a PTD also facilitates defining the biliary anatomy during the repair operation, especially in complex injuries [19, [23]. It would be very unlikely and uneconomical to dispose of such expertise in every hospital where a BDI can occur. Consequently, treatment availability influenced management strategy: most

patients were managed first by reoperation or ERCP, whereas PTC, which is less diffusely available in community hospitals, was most frequently performed after referral.

In our study nearly a half of the patients presented an injury progression. To a certain extent, injury progression can be considered an expected event, as in the case of strictures resulting from the healing of a lateral injury. Injury progression can also result from failed attempts at surgical repair, which frequently entail a more proximal involvement of the bile duct. This is observed in particular when a hepatico-jejunostomy is performed as the first treatment. For this reason, De Reuver et al. suggested that end-to-end anastomosis could be a reasonable option as a first-line repair [24]. In our series, however, the most frequent cause of injury progression was chronic cholangitis, issue of unrelieved bile duct stenosis and prolonged stenting, resulting in progressive ductal fibrosis. Consequently, some injuries initially limited to the bile duct eventually involved the confluence. We described the same mechanism of injury progression in a case of Mirizzi syndrome with persistent bile duct obstruction after laparoscopic cholecystectomy, which was finally managed with liver transplantation due to massive hilar plate fibrosis complicated by portal vein thrombosis [25]. Injury progression has been observed previously by many other Authors and in some cases it was associated with worse early and long-term outcome [22, 26, 27]. In our series grade $\geq$ E3 injuries were more likely to require a hepatic resection. Therefore, injury progression should be prevented as much as possible. Undoubtedly, as the denominator of our series (BDIs successfully managed in the hospital of origin and not referred) remains unknown, it is difficult to assess the magnitude of the problem. However, complex injuries and those not responding to initial treatment should be promptly referred to tertiary care centers and prolonged stenting should be avoided.

From a surgical standpoint, the most frequently applied technique was a hepaticojejunostomy on a Roux-n-Y loop, as previously reported [10, [13, [28, [29]. It should be noted that in most cases surgical repair requires a high degree of experience in hepatobiliary surgery: hilar plate dissection and identification of injured bile ducts is often difficult due to local inflammation and anatomical distortion. In our series, 17.1% of the patients required a hepatic resection and 11.4% a double barrel hepatico-jejunostomy. Patients presenting with a fistula required more frequently a double barrel hepaticojejunostomy. Furthermore, in 68.5% of the patients a transanastomotic drain was positioned due to doubts concerning bile duct quality. The use of a

transanastomotic drain is debatable. In the course of our experience, use of transjejunal drains was progressively abandoned due to their tendency to dislocate postoperatively. On the other hand, almost a half of the patients (9/20) having a PTD experienced some low-grade catheter-related complication. Our data do not allow formulating any recommendation; we can only argue that the incidence of bile leaks in our series can be considered low in the light of the severity of treated injuries.

Presentation with sepsis and need for laparotomy immediately after referral emerged as the only factors associated with severe complications, whereas no factor (including technical ones) resulted associated with long-term outcome. This stresses once more the importance of the right treatment from the very beginning. In contrast with previous reports [26], timing of intervention did not influence postoperative morbidity or treatment failure. This was true also at subgroup analysis of patients presenting with fistula (data not shown). This is in line with a previous study by Stewart et al. [30] showing that results of surgical repair may be acceptable regardless of timing, provided that sepsis and local inflammation have been previously controlled and that surgical repair is technically correct.

In conclusion, even nowadays some patients suffering from post-cholecystectomy BDI still experience an injury progression due to initial mismanagement and late referral. Treatment of BDI requires the integration of proper surgical technique with operative endoscopy and interventional radiology. Thus, these patients should be timely referred to tertiary care centers, especially those having a BDI presenting with sepsis or involving the biliary confluence.

Figure captions:

Fig. 1. Barplot representing injury grade distribution at the onset and at referral

Fig. 2. Kaplan-Meier curve representing failure-free survival. Median time to failure was 48 months.

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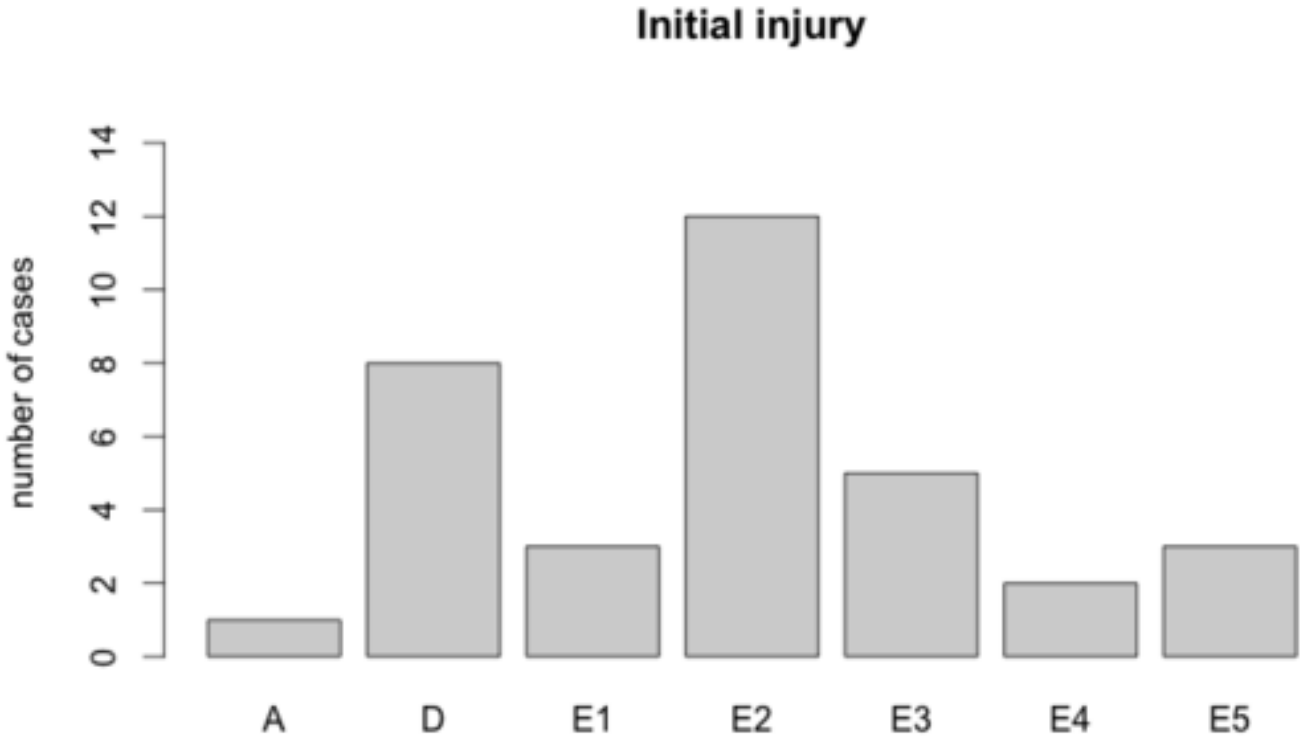
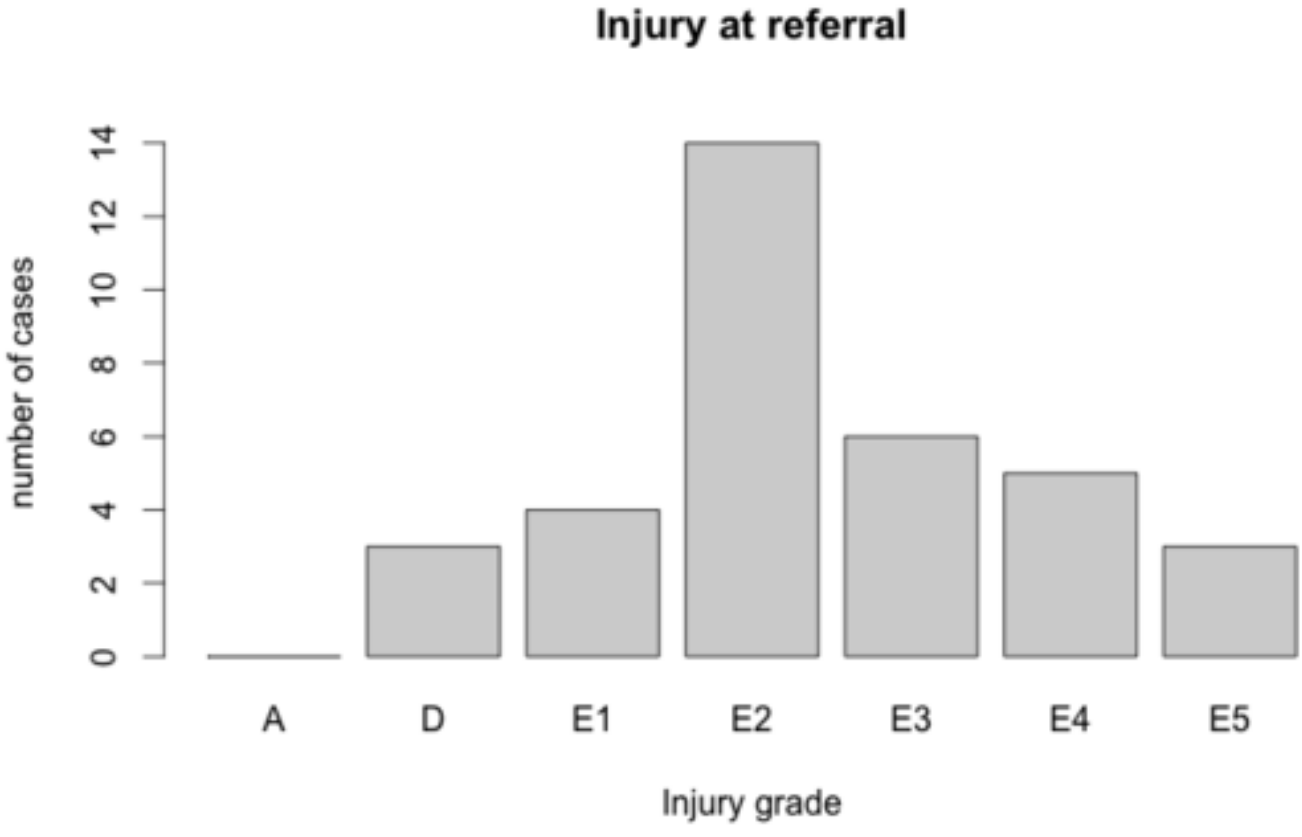
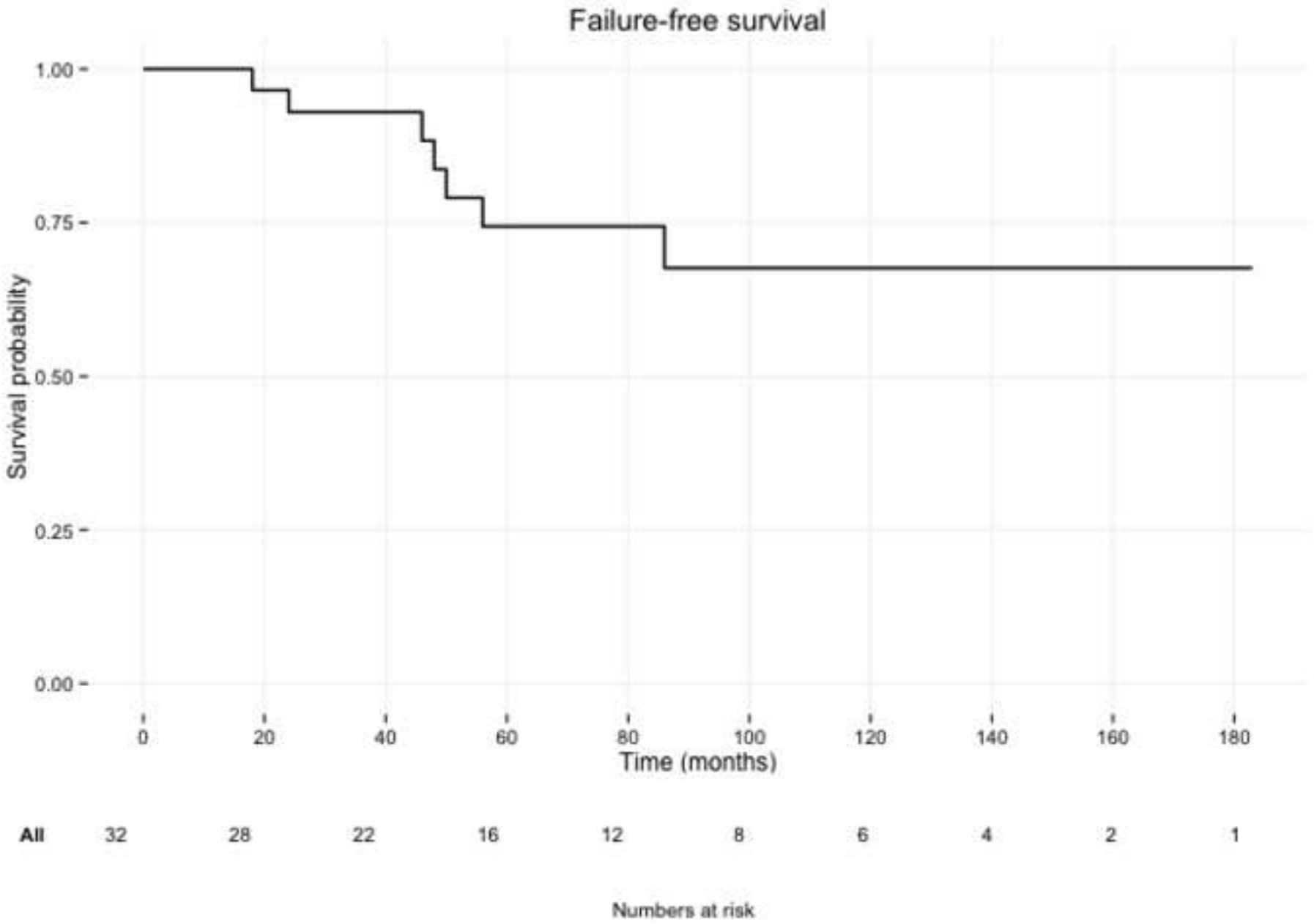

Initial injury
number of cases
0
2
4
6
8
10
12
14
A
D
E1
E2
E3
E4
E5


Injury at referral
number of cases
0
2
4
6
8
10
12
14
A
D
E1
E2
E3
E4
E5
Injury grade


Failure-free survival
1.00
0.75
0.50
0.25
0.00
Survival probability
0
20
40
60
80
100
120
140
160
180
Time (months)
All
32
28
22
16
12
8
6
4
2
1
Numbers at risk

Table

Table 1. Baseline, previous treatment and injury features according to the type of injury (stricture or fistula)

	Whole series	Stricture (n = 19)	Fistula (n = 16)	p
Age	57 (42 - 65)	53 (42 - 64)	60 (42 - 66)	0.55*
Sex (female/male)	21/14 (60%)	11/8 (57%)	10/6 (62.5%)	1
Indication				
- Gallstones	19 (54.3%)	5 (26.3%)	10 (62.5%)	0.06
- Acute cholecystitis	15 (42.8%)	13 (68.4%)	6 (37.5%)	
- Mirizzi syndrome	1 (2.8%)	1 (5.3%)	0	
ERCP prior to operation	2 (5.7%)	1 (5.3%)	1 (6.2%)	1
Technique				
- Open	11 (31.4%)	9 (47.4%)	2 (12.5%)	0.09
- Laparoscopic	14 (40%)	6 (31.6%)	8 (50%)	
- Laparoscopic converted to open	10 (28.6%)	4 (21%)	6 (37.5%)	
Intra-operative cholangiography	7 (20%)	5 (26.3%)	2 (12.5%)	0.41
Intra-operative detection	10 (28.6%)	5 (26.3%)	5 (31.2%)	0.7
Intra-operative repair attempt	7 (20%)	4 (21%)	3 (18.7%)	1
Technique of intra-operative repair				
- Suture + T-tube	3 (8.6%)	2 (10.5%)	1 (6.2%)	0.52
- Hepaticojejunostomy	2 (5.7%)	0	2 (12.5%)	
- Suture	1 (2.8%)	1 (5.3%)	0	
- Transcystic drain + drainage	1 (2.8%)	1 (5.3%)	0	
ERCP before referral	26 (74.3%)	16 (84.2%)	10 (62.5%)	0.24
PTC before referral	8 (22.8%)	5 (26.3%)	3 (18.7%)	0.7
Repair attempt before referral	7 (20%)	6 (31.6%)	1 (6.2%)	0.09
Technique of repair attempt before referral				
- Suture + T-tube	2 (5.7%)	2 (10.5%)	0	0.39
- Laparotomy without repair	2 (5.7%)	2 (10.5%)	0	
- Hepaticojejunostomy	1 (2.8%)	1 (5.3%)	0	
- End-to-end anastomosis + T-tube	1 (2.8%)	0	1 (6.2%)	
- Suture	1 (2.8%)	1 (5.3%)	0	
Injury grade at referral				
- D	3 (8.6%)	1 (5.3%)	2 (12.5%)	0.48
- E1	4 (11.4%)	3 (15.8%)	1 (6.2%)	
- E2	14 (40%)	8 (42.1%)	6 (37.5%)	
- E3	6 (17.1%)	4 (21%)	2 (12.5%)	
- E4	5 (14.3%)	3 (15.8%)	2 (12.5%)	
- E5	3 (8.6%)	0	3 (18.7%)	
Bifurcation involved (≥ E3)	13 (37.1%)	6 (31.6%)	7 (43.7%)	0.5
Grade ≥ E4	8 (22.8%)	3 (15.8%)	5 (31.2%)	0.42
Vasculo-biliary injury	4 (11.4%)	1 (5.3%)	3 (18.7%)	0.31
- Arterial injury	2 (5.7%)	0	2 (12.5%)	
- Portal injury	1 (2.8%)	1 (5.3%)	0	
- Combined arterial + portal	1 (2.8%)	0	1 (6.2%)	
Sepsis at referral	7 (20%)	0	7 (43.7%)	**0.001**

Data are expressed as median (interquartile range) or number (percentage). Fisher's exact test and Mann-Whitney test (*) were used to compare variables among different groups. Abbreviations: ERCP, endoscopic retrograde cholangio-pancreatography; PTC, percutaneous transhepatic cholangiography

Table

Table 2. Injury progression according to the type of injury at referral

	Whole series (n = 35)	Stricture (n = 19)	Fistula (n = 16)	p*
Injury progression	15 (42.8%)	12 (63.1%)	3 (18.7%)	0.001
Progression type				
- More proximal involvement of the bile duct	8 (22.8%)	6 (31.6%)	2 (12.5%)	
- Fistula evolving to more proximal stricture	4 (11.4%)	4 (21%)	0	
- Development of secondary biliary cirrhosis	2 (5.7%)	2 (10.5%)	0	
- Development of hepatic fibrosis	2 (5.7%)	2 (10.5%)	0	
- Secondary biliary cirrhosis + portal vein cavernoma	1 (2.8%)	1 (5.3%)	0	
- Right bile duct necrosis after PTC	1 (2.8%)	0	1 (6.2%)	

Data are expressed as number (percentage). * Fisher exact test. In some patients types of injury progression overlapped.

Table

Table 3. Treatment according to the type of injury at referral

	Whole series (n = 35)	Stricture (n = 19)	Fistula (n = 16)	p
Days from injury to referral	44 (11-651)	577 (126-3037)	14 (7-25)	**<0.001***
Treatment after referral				
- Laparotomy§	3 (8.6%)	1 (5.3%)	2 (12.5%)	0.58
- PTC	13 (37.1%)	7 (36.8%)	6 (37.5%)	1
- ERCP	0	0	0	1
- Percutaneous drainage of bile collection	6 (17.1%)	0	6 (37.5%)	**0.004**
Type of repair				
- Hepaticojejunostomy	26 (74.3%)	17 (89.5%)	9 (56.2%)	0.07
- Hepaticojejunostomy + hepatic resection	4 (11.4%)	1 (5.3%)	3 (18.7%)	
- Double barrel hepaticojejunostomy	2 (5.7%)	0	2 (12.5%)	
- Double barrel hepaticojejunostomy + hepatic resection	1 (2.8%)	0	1 (6.25%)	
- Direct repair + T-tube	1 (2.8%)	0	1 (6.25%)	
- Liver transplantation	1 (2.8%)	1 (5.3%)	0	
Hepatic resection	6 (17.1%)	2 (10.5%)	4 (25%)	0.37
- Right hepatectomy	2 (33.3%)	0	2 (50%)	
- Left hepatectomy	2 (33.3%)	1 (50%)	1 (25%)	
- Right lobectomy	1 (16.7%)	0	1 (25%)	
- Liver transplantation	1 (16.7%)	1 (50%)	0	
Number of biliary anastomoses				
- 0	1 (2.8%)	0	1 (6.25%)	**0.01**
- 1	30 (85.7%)	19 (100%)	11 (68.7%)	
- 2	4 (11.4%)	0	4 (25%)	
Transanastomotic drain				
- None	10 (28.6%)	7 (36.8%)	3 (18.75%)	0.34
- Transhepatic	20 (57.1%)	10 (52.6%)	10 (62.5%)	
- Transjejunal	4 (11.4%)	2 (10.5%)	2 (12.5%)	
- T-tube	1 (2.8%)	0	1 (6.25%)	

Data are expressed as median (interquartile range) or number (percentage). Fisher's exact test and Mann-Whitney (*) test were used for variables comparison. § Patients requiring laparotomy after referral prior to definitive surgical repair. Abbreviations: PTC, percutaneous transhepatic cholangiography; ERCP, endoscopic retrograde cholangiopancreatography.

Table

Table 4. Postoperative and long-term outcome

Postoperative outcome

	Whole series (n = 35)	Stricture (n = 19)	Fistula (n = 16)	p
Length of stay (days)	14 (10-22)	12 (8-22)	14 (11-23)	0.29*
Grade 1 – 2 complication	15 (42.8%)	10 (52.6%)	5 (31.25%)	0.30
Grade 3 – 4 complication	12 (34.3%)	5 (26.3%)	7 (43.75%)	0.31
Postoperative death	1 (2.8%)	0	1 (6.25%)	0.45
Transhepatic drain complication	9 (25.7%)	5 (26.3%)	4 (25%)	1
- Drain dislocation	3 (33.3%)	3 (15.8%)	0	
- Cholangitis	2 (22.2%)	1 (5.3%)	1 (6.25%)	
- Cholangitis + drain dislocation	1 (11.1%)	0	1 (6.25%)	
- Bile duct obstruction	1 (11.1%)	1 (5.3%)	0	
- Biliary leak	1 (11.1%)	0	1 (6.25%)	
- Subcapsular hematoma	1 (11.1%)	0	1 (6.25%)	
Biliary leak	4 (11.4%)	1 (5.3%)	3 (18.75%)	0.31
Cholangitis	4 (11.4%)	1 (5.3%)	3 (18.75%)	0.31
Bleeding	1 (2.8%)	1 (5.3%)	0	1
Posthepatectomy liver failure	1 (2.8%)	0	1 (6.25%)	0.46

Long-term outcome[§]

	Whole series (n = 32)	Stricture (n = 17)	Fistula (n = 15)	
Anastomotic stricture	7 (21.9%)	4 (23.5%)	3 (20%)	1
Outcome				
- Good	22 (68.7%)	10 (58.8%)	12 (80%)	0.28
- Fair	3 (9.4%)	3 (17.6%)	0	
- Failure	7 (21.9%)	4 (23.5%)	3 (20%)	

Data are expressed as median (interquartile range) or number (percentage). Fisher exact test and Mann-Whitney test (*) were used to compare variables among different groups. Dindo-Clavien classification was applied to postoperative complications. [§] One patient died in the postoperative period and two patients lost to follow-up were excluded from analysis.

Table

Table 5. Results of univariate logistic regression of variables associated with severe (≥3b) postoperative complications

	OR	2.5%	97.5%	p
Age	1.04	0.001	1.13	0.18
Sex (male)	0.7	0.08	4.26	0.71
Index operation technique:				
- laparoscopic versus converted	0.38	0.04	2.89	0.35
- open versus converted	0.23	0.01	2.26	0.24
Intraoperative injury diagnosis	1.31	0.15	8.22	0.77
Intraoperative repair attempt	2.4	0.27	16.49	0.37
Grade ≥ E3 injury	4.44	0.73	36.58	0.11
Grade ≥ E4 injury	4.8	0.71	33.81	0.09
Vasculo-biliary injury	1.73	0.07	17.17	0.66
Surgical repair attempt before referral	1.91	0.22	12.62	0.5
ERCP before referral	0.63	0.09	5.29	0.64
PTC before referral	0.62	0.03	4.85	0.69
PTC after referral	0.81	0.1	4.95	0.83
Laparotomy after referral*	14	1.1	347.15	**0.04**
Percutaneous bile collection drainage	3.12	0.35	22.96	0.26
Delay ≥ 6 weeks after injury	0.46	0.05	2.78	0.41
Stricture versus fistula	0.35	0.04	2.11	0.27
Previous cholangitis	1.63	0.26	10.27	0.58
Sepsis at referral	17.33	2.41	176.24	**0.007**
Hepatic resection	3.12	0.35	22.96	0.26
Anastomosis stenting by transhepatic drain	4.67	0.64	95.37	0.18

Results are expressed as odds ratio and 95% confidence interval. *Laparotomy performed after referral prior to definitive surgical repair. Abbreviations: ERCP, endoscopic retrograde cholangio-pancreatograhy; PTC, percutaneous transhepatic cholangiography.