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REVIEW ARTICLE

Management of Post-Cholecystectomy Benign Bile Duct Strictures: Review

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Abstract Cholecystectomy is one of the common surgical procedure performed across the world and bile duct injury is a dreaded complication. The present review addresses the classification of injuries, preoperative preparation and evaluation of these patients and appropriate timing of surgery. A detailed preoperative evaluation combined with a meticulous wide anastomosis by experienced surgeons is the key in achieving long term success. Vascular injuries and its consequences on repair and outcome is also reviewed. Long term results of surgical repair and quality of life in these patients are excellent

Keywords Cholecystectomy · Bile duct · Benign biliary stricture · Bile duct injury

Introduction

Bile duct injuries (BDI), occurring most commonly after cholecystectomy, present a formidable challenge that requires a multidisciplinary approach for optimum management. If unrecognized or managed inappropriately these injuries may not only lead to potentially serious complications such as cholangitis, biliary cirrhosis, and portal hypertension but also entail considerable cost, loss of work, and litigation. The advent of laparoscopic cholecystectomy (LC) and its rapid establishment as the gold standard for management of gallstone disease has refocused attention on BDI, their incidence, and management.

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The incidence of BDI during open cholecystectomy is reported to be approximately 0.1–0.2% [1–3]. The exact incidence of BDI following LC is not known, but is definitely higher than that following open cholecystectomy and reportedly varies between 0.4% and 0.6% [4–10]. It is also felt that biliary injuries following LC are more severe and complex than that encountered during an open cholecystectomy [11, 12].

Classification of Bile Duct Injury

In order to define the types of BDI, several classifications of BDI have been proposed, but none is universally accepted as each of them has its own limitations. Of these, Bismuth's classification and Strasberg's classification are most commonly used by clinicians. Bismuth's classification [13] addresses the group of patients presenting with established biliary stricture and stratifies patients based on the level of injury, which is an important determinant of outcome. Sikora et al. [14] modified the type 3 strictures into type 3a/3b depending on the floor of the confluence being intact or destroyed. Strasberg's classification [10] is applicable for acute injuries with bile leak, lateral injuries, and transection. The transection subgroup (type E) incorporates the Bismuth's classification. The major drawback of these classifications is that some important factors that influence the outcome are not accounted for, such as vascular injuries; timing of recognition of injury; presence of biliary fistula (external/internal); portal hypertension; atrophy/hypertrophy complex; and previous repairs, if any. The Hannover classification [15] is the most refined in terms of combining the Bismuth's and Strasberg's classification and has also addressed the vascular injuries. Hopefully, a universally accepted comprehensive classification system will be seen in the near future encompassing all the relevant parameters influencing long-term outcome [16].

Preoperative Work-Up and Preparation

A detailed work-up and a meticulous preoperative preparation are important determinants of a successful management of a patient with BDI. The aim of preoperative work-up is to document the extent of liver dysfunction, establish the exact level and type of stricture, and to investigate for possible complications such as secondary biliary cirrhosis (SBC) and portal hypertension or an atrophy/hypertrophy complex. It is also equally important to diagnose associated medical risk factors, especially coexisting liver disease, and to detect and correct any existing nutritional, fluid-electrolyte, and coagulation disorders and control infection.

A complete hematological profile, liver and renal function tests, and a coagulation profile are obtained. Radiological imaging with ultrasound (US) and computed tomography (CT) are helpful in the initial evaluation of patients with biliary injuries. In the early period after injury, intra-abdominal collections can be demonstrated (and drained under US or CT guidance). In the later period, proximal biliary dilatation, level of biliary obstruction, and intrahepatic sludge/stones are well shown and CT may also show evidence of vascular injury and reveal atrophy/ hypertrophy complex, if present.

However, the cross-sectional imaging modalities do not provide the detailed anatomical information on the type and extent of stricture, for which a cholangiographic examination is mandatory.

Cholangiography

The aim of cholangiographic evaluation is to define the Bismuth type of the stricture and document the extent of ductal dilatation. The entire biliary tree (all branches of the right and left intrahepatic biliary tree and the confluence—if intact) must be outlined for a complete assessment. This is accomplished by either a fistulogram, if there is an external biliary fistula or by a percutaneous transhepatic cholangiography (PTC). PTC should be performed either a day prior to or on the day of surgery under strict asepsis and parenteral antibiotic cover. All segmental ducts should be delineated (if required by multiple punctures) in order to define the type of stricture. Magnetic resonance cholangiopancreatography (MRCP) has now been accepted as the gold standard for noninvasive cholangiographic assessment of the biliary system. MRCP can diagnose biliary obstruction with a high sensitivity and specificity [17]. The sensitivity for the detection of biliary strictures is lower (67%), although the specificity remains high (98%) [18]. The ability of MRCP to provide anatomical details of the biliary as well as the vascular tree, along with a cross-sectional imaging to assess for atrophy/hypertrophy, etc. in a noninvasive manner makes it a potentially valuable tool in the evaluation of BDI [19, 20]. In the era of MRCP, an invasive PTC is recommended in complex biliary strictures, especially Bismuth type 4 or 5 stricture with undilated ducts for a complete delineation of all ductal systems.

Timing of Surgical Intervention

The timing of repair of BDI is critical, especially when one realizes that the first attempt at repair is the best in terms of success and long-term results. In an elective situation, a minimum period of 4–6 weeks between injury and repair is desirable for resolution of tissue edema and inflammation and for dilatation of the proximal ductal system [21, 22]. In patients with an external biliary fistula (EBF), the injury–repair interval may be extended to 8–12 weeks, provided management of EBF is not complicated by fluid and electrolyte disturbances and skin problems. Undue haste in trying to deal with the injury by repair at an early stage is fraught with a high risk of bile leak (30%), stricture formation (25%), and even death (30%) [23].

Surgical Reconstruction

The definitive management of biliary stricture involves restoration of bile flow into the proximal gastrointestinal tract in a manner that prevents further cholangitis, sludge/ stone formation, re-stricture, or progressive liver injury. Surgical reconstruction remains the gold standard against which other techniques such as percutaneous or endoscopic balloon dilatation and stenting need to be compared.

Hepaticojejunostomy is the common method of repair for BDI. The key surgical principles associated with a successful repair of BDI are exposure of healthy, well-vascularized proximal bile ducts that drain the entire liver, and preparation of a suitable segment of intestine (most often a Roux-en-Y limb of jejunum >60 cm) for a mucosa-to-mucosa, tension-free anastomosis between the well-vascularized proximal bile duct/s and the jejunum.

The Hepp-Couinaud technique [24, 25] of accessing the left duct under the base of quadrate lobe, where it runs a rather long extrahepatic course, provides a satisfactory and reliable method of locating the proximal duct. Lowering of the hilar plate by incising the Glisson's capsule at the base of quadrate lobe (segment 4) and incising the vasculobiliary sheath expose the main left hepatic duct, the confluence, and the origin of the right hepatic duct. It is not necessary to dissect and identify the distal bile duct or to resect the strictured segment (unless there is a suspicion of a malignant stricture), as it entails a potential risk for injury to the portal vein and hepatic artery. A side-to-side hepaticojejunostomy made by a longitudinal incision of extrahepatic left hepatic duct produces a wide anastomosis, minimizes dissection behind the biliary ducts, and decreases the risk of devascularization of the ducts [26, 27].

Other procedures, which may be very rarely required in complex strictures where the conventional approach has failed, include the intrahepatic hepaticojejunostomy described by Longmire and Sanford [28] and the Smith's mucosal graft [29]. In difficult strictures with confluence involvement, excision of the base of segment 4 to access the healthy, vascularized proximal duct to perform a tension-free intrahepatic anastomosis has yielded excellent results [30, 31].

The use of transanastomotic stents remains controversial. Some groups [32] use them routinely in all cases (starting with preoperative placement to facilitate intraoperative duct dissection and identification). The premise being that in the early postoperative period, stents provide decompression of biliary tree, access for cholangiography or percutaneous interventional procedures, and over long term ensure a stable biliary anastomosis during the period of healing and scar contracture. Most groups [33–35] reserve stenting for difficult repairs. We do not routinely stent our bilioenteric anastomosis. In case of undilated system (duct diameter <5 mm), high strictures with unhealthy tissues, and unsatisfactory mucosa-to-mucosa anastomosis, we prefer to stent the patients for a period of 6–12 months. For long-term stenting, a transhepatic, transanastomotic stent placement is preferred, since the transjejunal stents are prone to migration and slipping [36].

Partial hepatic resection may be required in a proportion of patients (12–15%) to manage complex biliary injuries, liver atrophy secondary to associated vascular injuries, and multiple failed previous repairs [37–41]. Liver resection removes the fibrotic, atrophic segment and the diseased biliary confluence, thereby providing good access to the remnant bile duct for a safe healthy anastomosis [39, 40]. Resections can be performed successfully with low/zero mortality, although with significant morbidity (50–60%) with excellent long-term success of 94% [39–41].

Liver transplantation is rarely indicated in patients with SBC and decompensation or in those with acute vascular injury and acute liver failure [41]. Several small series and case reports of transplant in the setting of biliovascular injury have been reported with mixed results [42–44]. Liver transplant in the setting of biliary injury is a complex exercise associated with significant morbidity and mortality [40, 41].

Associated Arterial Injury

The incidence of arterial injury following cholecystectomy is highly variable depending on the cohort of patients being evaluated and whether angiographic assessment is done as a matter of routine. The incidence of hepatic arterial injury after cholecystectomy has been estimated to be 7% in an autopsy series of cadavers who had undergone an uneventful open cholecystectomy [45]. Deziel et al. [7] reported 44 cases with hepatic arterial injury after LC in 77,604 patients (0.06%). The incidence of arterial injury is higher, ranging between 12% and 39% [6, 46, 47], in patients who also have a concomitant BDI. Chapman et al. [33] showed in a large study that combined hepatic arterial injury was demonstrated in 18 of 130 (13.8%) patients with BDI after "open cholecystectomy". Routine celiac and superior mesenteric angiography in patients with major BDI reported 47% incidence of hepatic arterial injuries [48]. Right hepatic artery, or the replaced right hepatic artery is the most common artery to be disrupted. Injuries present either as occlusion, pseudoaneurysm, or complete disruption. Combined biliovascular injury may result in hepatic lobar ischemia, necrosis, and sepsis, with catastrophic outcome [49, 50].

There is no consensus on whether or not to perform preoperatively a selective angiography in patients with major BDI. In addition, there seems to be no definite recommendations on whether or not to perform arterial reconstruction for combined biliovascular injury. Gupta et al. [51] reported three patients with right hepatic arterial occlusion combined with BDI during LC in whom arterial reconstruction was not performed. They showed that the arterial occlusion is a crucial risk factor for postoperative morbidity because liver necrosis, liver abscess, or ischemic injury of the intrahepatic bile duct can occur after reconstructive hepaticojejunostomy. They also reported that combined right arterial injury causes not only recurrent stenosis of hepaticojejunostomy but also delayed stricture of the intrahepatic biliary tract in long-term outcome. Madariaga et al. [52] reported that inadvertent occlusion of the right hepatic artery was present in 5 of 14 patients with BDI after LC. They reported that right lobe ischemia and bile duct ischemia were serious in three of the five patients with right hepatic arterial occlusion. Right hepatic arterial reconstruction was needed in one patient because of right hepatic lobe ischemia. In the other two patients, initial hepaticojejunostomy failed and right lobectomy with revision of biliary reconstruction was needed. Bachellier et al. [27] performed arterial repair in two of the three patients with combined bile duct and right hepatic artery injuries with excellent results over long term.

In contrast, Alves et al. [48] and Stewart et al. [53] observed combined biliovascular injury in 47% and 32% of patients, respectively, but there was no difference in the morbidity and long-term outcome in patients with or without concomitant vascular injury.

Preoperative angiography should be routinely performed to investigate combined arterial injury in patients with complex or high biliary injury during LC. In acute injuries, arterial reconstruction should be performed when the distal right hepatic artery can be exposed and can be reconstructed to prevent re-stenosis and ischemic complications. Biliary repair in this scenario is associated with a high morbidity and mortality [54–57]. In patients with delayed presentation, high anastomosis to the left duct and confluence ensures excellent long-term patency, as there is good revascularization by a robust collateral circulation via the hilar plate [48, 49].

Biliary Stricture and Portal Hypertension

Portal hypertension is seen in 7–20% of patients with BDI. Prolonged biliary obstruction leading to secondary biliary fibrosis/cirrhosis is the most common cause of portal hypertension [33, 36, 58, 59]. Occasionally, portal vein injury with cavernoma formation or portal vein thrombosis due to recurrent cholangitis may lead to portal hypertension (PH). SBC is uncommon and incidence varies from 8% to 18% in various series [36, 58]. Risk factors for the development of portal hypertension and/or SBC in patients with benign biliary stricture include long duration of obstruction as indicated by a long symptomatic period, a long interval between cholecystectomy and hepaticojejunostomy, a history of cholangitis (especially recurrent attacks), and previous attempts at repair [36, 58, 60, 61]. The approach to patients with BDI and PH is dictated by the level of injury, severity of portal hypertension, and hepatoduodenal collaterals and whether there is portal vein injury with thrombosis of cavernoma formation. In patients with portal vein cavernoma and extensive collaterals in the hepatoduodenal ligament, a staged approach with portasystemic shunt followed by a hepaticojejunostomy is the preferred approach. In majority of patients with SBC and mild-to-moderate PH, single-stage approach with a Roux-Y hepaticojejunostomy can be safely performed with excellent long-term results [36, 58, 59]. This subgroup of patients is difficult to manage, and surgical repair is associated with high operative mortality (26–36% in patients with portal hypertension vs 8% in patients without portal hypertension) [33, 58, 60].

Results of Surgical Reconstruction

Operative Morbidity and Mortality

Compared with earlier reports, where the mortality ranged from 5% to 8% [62, 63], in the last decade there has been a considerable decline in the operative mortality with many large series reporting zero perioperative deaths [64–67]. Considering that these results are from tertiary care centers where more severe injuries would be referred, usually after one or more previous attempts at repair, surgical reconstruction is a safe procedure in experienced hands. The factors that adversely affect survival [63, 68] following repair include advanced age, significant comorbid medical conditions, biliary sepsis, and significant underlying liver disease. In patients with coexisting portal hypertension, mortality has been reported to be as high as 23% [33]. The morbidity is usually in the form of postoperative bile leak, cholangitis, intra-abdominal abscess, hemorrhage, and wound infection.

Long-Term Results

Several factors need to be considered when discussing long-term results following stricture repair.

Duration of follow-up: The need for prolonged follow-up cannot be over-emphasized. It has been seen that although two-thirds of failure occur within 2 years and 80% within 5 years, as many as 20% of failures may occur after 5 years [68]. In one series [67], 40% of re-strictures were identified more than 5 years following the initial surgery. Hence, a minimum follow-up of 5 years or even more is required for assessment of results. Thus, the duration of follow-up is

Table 1 Long-term results in patients with postcholecystectomy benign bile duct strictures

References	N	Type III–V (%)	Overall failure (%)	Median follow-up (years)
Bottger and Junginger [70]	173	34	11	9.4
Chapman et al. [33]	130	61	21	7.2
Lillemoe et al. [32]	156	55	9.2	4.9
Sikora et al. [36]	300	51	5	7.5
deReuver et al. [21]	151	27	10	4.5
Winslow et al. [26]	113	44	4.4	4.9
Moossa [71]	81	24.6	27	2
McDonald et al. [67]	45	31	40	4.6
Raute et al. [66]	48	43.7	18	7.4

important when comparing results of different series as well as different treatment modalities.

Methods of follow-up: Although the exact system of evaluation may vary, most authors take into consideration the patients' symptoms, liver function tests, and the need for repeat intervention while categorizing the results. McDonald et al. [67] have suggested a system of grading, incorporating the symptoms, liver function tests, and the need for further intervention. In this system, the results are classified as grade A (normal liver function tests (LFT) results, asymptomatic); grade B (mild elevation LFT results, asymptomatic); grade C (abnormal LFT results, cholangitis, pain); and grade D (surgical revision or dilatation required). Chapman et al. [33] have also incorporated hepatobiliary iminodiacetic acid (HIDA) scan in assessment of these patients. Although the need for repeat intervention for re-stricture is taken as a poor result, subsequent salvage by surgery or nonsurgical methods is finally included as a good result by many. A triad of criteria incorporating symptoms, biochemistry, and radiology has been proposed to facilitate comparison of results between series as well as different treatment modalities [69].

Sikora et al. [61] have proposed a modification in the follow-up grading system by suggesting that in addition to the above parameters, liver biopsy and grading of fibrosis should be an integral part of the grading algorithm. Patients with varying degrees of liver fibrosis and cirrhosis may have derangement of liver function tests despite a patent bilioenteric anastomosis documented on HIDA. These patients should be classified as good outcome and not be condemned as fair outcome.

Most large series from tertiary care centers report a satisfactory outcome in 80–90% of patients (Table 1). Important factors reported in various series as predictors of adverse outcome include proximal strictures (Bismuth type 3 and 4), multiple prior attempts at repair, presence of hepatic parenchymal disease, portal hypertension, end-to-end biliary anastomoses, surgeon's inexperience, and biliary sepsis.

Quality-of-Life Issues

Psychosocial repercussions of BDI are immense considering the fact that these patients are in the most productive years of their lives and often have nondisabling symptoms. They are prepared for a minimally invasive, perhaps daycare, quick-recovery procedure and then when faced with a serious complication requiring a major surgical repair by a specialist, it takes its toll. Despite excellent results of surgery with good long-term patency, the quality-of-life (QOL) outcomes have not been well documented. Few studies reporting the QOL outcomes suggest paradoxical results; endoscopic treatment and long duration of treatment [72], and patients involved in litigation [73] have poor mental QOL results. Although nonsurgical treatment is touted as a less invasive, efficacious option, QOL results suggest that a good surgical repair is associated with as good results as that following a cholecystectomy [74].

Conclusions

Prevention is the best treatment of biliary strictures. Surgeons should pay attention to the caveats for a safe dissection to prevent BDI during LC.

Biliary injury when detected should be managed at centers where surgeons, endoscopists, and interventional radiologists are available to ensure appropriate early and delayed management. The first attempt at repair is the best chance for a long-term success and this should be performed at centers with experience in biliary surgery. A proximal side-side hepaticojejunostomy is the treatment of choice for most patients, and long-term follow-up is imperative to identify late problems.

References

1. Gilliland TM, Traverso LW (1990) Modern standards for comparison of cholecystectomy with alternative treatments for symptomatic cholelithiasis with emphasis on long-term relief of symptoms. Surg Gynecol Obstet 170:39–44
2. Mcsherry CK (1989) Cholecystectomy: the gold standard. Am J Surg 158:174–178
3. Andren-Sandberg A, Allinder G, Bengmark S (1985) Accidental lesions of the common bile duct at cholecystectomy. Ann Surg 201:328–332
4. Perrisat J (1993) Laparoscopic cholecystectomy: the European experience. Am J Surg 165:444–449
5. Lee VS, Chari RS, Cucchiaro G, Meyers WC (1993) Complications of laparoscopic cholecystectomy. Am J Surg 165:527–532
6. Davidoff AM, Pappas TN, Murray EA, Hilleren DJ, Johnson RD, Baker ME et al (1992) Mechanisms of major biliary injury during laparoscopic cholecystectomy. Ann Surg 215:196–202
7. Deziel DJ, Millikan KW, Economou SG, Doolas A, Ko ST, Airan MC (1993) Complications of laparoscopic cholecystectomy: a national survey of 4292 hospitals and an analysis of 77,604 cases. Am J Surg 165:9–14
8. Woods MS, Traverso LW, Kozarek RA, Tsao J, Rossi RL, Gough D, Donohue JH (1994) Characteristics of biliary tract complications during laparoscopic cholecystectomy: a multi-institutional study. Am J Surg 167:27–34
9. The Southern Surgeons club (1991) A prospective analysis of 1518 cholecystectomies. N Engl J Med 324:1073–1078
10. Strasberg SM, Hertl M, Soper NJ (1995) An analysis of the problem of biliary injury during laparoscopic cholecystectomy. J Am Coll Surg 180:101–125
11. Sikora SS, Kumar A, Das NR, Sarkari A, Saxena R, Kapoor VK (2001) Laparoscopic bile duct injuries: spectrum at a tertiary-care center. J Laproendosc Adv Surg Tech A11:63–68

12. Chaudhary A, Manisegran M, Chandra A, Agarwal AK, Sachdev AK (2001) How do bile duct injuries sustained during laparoscopic cholecystectomy differ from those during open cholecystectomy? J Laparoendosc Adv Surg Tech A 11(4):187–191
13. Bismuth H, Majno PE (2001) Biliary strictures: classification based on the principles of surgical treatment. World J Surg 25:1241–1244
14. Sikora SS, Srikanth G, Sarkari A, Kumar A, Saxena R, Kapoor VK (2003) Hilar benign biliary strictures: need for subclassification. ANZ J Surg 73(7):484–488
15. Bektas H, Schrem H, Winny M, Klempnauer J (2007) Surgical treatment and outcome of iatrogenic bile duct lesions after cholecystectomy and the impact of different clinical classification systems. Br J Surg 94(9):1119–1127
16. Lau WY, Lai EC (2007) Classification of iatrogenic bile duct injury. Hepatobiliary Pancreat Dis Int 6(5):459–463
17. Hintze RE, Adler A, Veltzke W, Abou-Rebyeh H, Hammerstingl R, Vogl T et al (1997) Clinical significance of magnetic resonance cholangiopancreatography (MRCP) compared to endoscopic retrograde cholangiopancreatography (ERCP). Endoscopy 29:182–187
18. Mendler MH, Bouillet P, SautereauD CP, Cessot F, Le Sidaner A et al (1998) Value of MR cholangiography in the diagnosis of obstructive diseases of the biliary tree: a study of 58 cases. Am J Gastroenterol 93:2482–2490
19. Coakley FV, Schwartz LH, Blumgart LH, Fong Y, Jarnagin WR, Panicek DM et al (1998) Complex postcholecystectomy biliary disorders: preliminary experience with evaluation by means of breath-hold MR cholangiography. Radiology 209:141–146
20. Chaudhary A, Negi SS, Puri SK, Narang P (2002) Comparison of magnetic resonance cholangiography and percutaneous transhepatic cholangiography in the evaluation of bile duct strictures after cholecystectomy. Br J Surg 89(4):433–436
21. deReuver PR, Grossmann I, Busch OR, Obertop H, van Gulik TM, Gouma DJ (2007) Referral pattern and timing of repair are risk factors for complications after reconstructive surgery for bile duct injury. Ann Surg 245(5):763–770
22. Goykhman Y, Kory I, Small R, Kessler A, Klausner JM, Nakache R, Ben-Haim M (2008) Long-term outcome and risk factors of failure after bile duct injury repair. J Gastrointest Surg 12(8):1412–1417
23. Schol FP, Go PMNYH, Gouma DJ (1995) Outcome of 49 repairs of bile duct injuries after laparoscopic cholecystectomy. World J Surg 19:753–756
24. Hepp J (1985) Hepaticojejunostomy using the left biliary trunk for iatrogenic biliary lesions. World J Surg 9:507–511
25. Blumgart LH, Kelly CJ (1984) Hepaticojejunostomy in benign and malignant high bile duct stricture: approaches to the left ducts. Br J Surg 71:257–261
26. Winslow ER, Fialkowski EA, Linehan DC, Hawkins WG, Picus DD, Strasberg SM (2009) “Sideways”: results of repair of biliary injuries using a policy of side-to-side hepatico-jejunostomy. Ann Surg 249(3):426–434
27. Bachellier P, Nakano H, Weber JC, Lemarque P, Oussoultzoglou E, Candau C, Wolf P, Jaeck D (2001) Surgical repair after bile duct and vascular injuries during laparoscopic cholecystectomy: when and how? World J Surg 25(10):13351345
28. Longmire WP, Sanford MC (1948) Intrahepatic cholangiojejunostomy with partial hepatectomy for biliary obstruction. Surgery 128:330–347
29. Smith R (1981) Injuries of the bile ducts. In: Smith LR, Sherlock DS (eds) Surgery of the gallbladder and bile ducts. Butterworths, London, pp 361–381
30. Mercado MA, Chan C, Orozco H, Villalta JM, Barajas-Olivas A, Eraña J, Domínguez I (2006) Long-term evaluation of biliary reconstruction after partial resection of segments IV and V in iatrogenic injuries. J Gastrointest Surg 10(1):77–82
31. Mercado MA, Chan C, Salgado-Nesme N, López-Rosales F (2008) Intrahepatic repair of bile duct injuries. A comparative study. J Gastrointest Surg 12(2):364–368
32. Lillemoe KD, Melton GB, Cameron JL, Pitt HA, Campbell KA, Talamini MA et al (2000) Post operative bile duct strictures: management and outcome in the 1990s. Ann Surg 232:430–441
33. Chapman WC, Halvey A, Blumgart LH, Benjamin IS (1995) Postcholecystectomy bile duct strictures. Arch Surg 130:597–604
34. Stewart L, Way LW (1995) Bile duct injuries during laparoscopic cholecystectomy: factors that influence the results of treatment. Arch Surg 130:1123–1129
35. Tocchi A, Costa G, Lepre L, Liotta G, Mazzoni G, Sita A (1996) The long-term outcome of hepaticojejunostomy in the treatment of benign bile duct strictures. Ann Surg 224:162–167
36. Sikora SS, Pottakkat B, Srikanth G, Kumar A, Saxena R, Kapoor VK (2006) Postcholecystectomy benign biliary strictures—long-term results. Dig Surg 23(5–6):304–312
37. Schmidt SC, Langrehr JM, Raakow R, Klupp J, Steinmüller T, Neuhaus P (2002) Right hepatic lobectomy for recurrent cholangitis after combined bile duct and right hepatic artery injury during laparoscopic cholecystectomy: a report of two cases. Langenbecks Arch Surg 387:183–187
38. Heinrich S, Seifert H, Krähenbühl L, Fellbaum C, Lorenz M (2003) Right hemihepatectomy for bile duct injury following laparoscopic cholecystectomy. Surg Endosc 17:1494–1495
39. Lichtenstein S, Moorman DW, Malatesta JQ, Martin MF (2000) The role of hepatic resection in the management of bile duct injuries following laparoscopic cholecystectomy. Am Surg 66(4):372–376
40. Laurent A, Sauvanet A, Farges O, Watrin T, Rivkine E, Belghiti J (2008) Major hepatectomy for the treatment of complex bile duct injury. Ann Surg 248(1):77–83
41. Thomson BN, Parks RW, Madhavan KK, Garden OJ (2007) Liver resection andtransplantation in the management of iatrogenic biliary injury. World J Surg 31:2363–2369
42. deSantibañes E, Ardiles V, Gadano A, Palavecino M, Pekolj J, Ciardullo M (2008) Liver transplantation: the last measure in the treatment of bile duct injuries. World J Surg 32(8):1714–1721
43. Ozden I, Bilge O, Tekant Y, Alper A, Emre A, Arioğul O (2008) Liver transplantation in the management of iatrogenic biliary tract injury. World J Surg 32(6):1230
44. Fernandez JA, Robles R, Marin C, Sanchez-Bueno F, Ramirez P, Parrilla P (2004) Laparoscopic iatrogeny of the hepatic hilum as an indication for liver transplantation. Liver Transpl 10:147–152
45. Halasz NA (1991) Cholecystectomy and hepatic artery injury. Arch Surg 126:137–138
46. Wudel LJ, Wright JK, Pinson CW et al (2001) Bile duct injury following laparoscopic cholecystectomy: a cause for continued concern. Am Surg 67:557–563
47. Bismuth H (1981) How to treat a postoperative stenosis? In: Bismuth H, Lazorthes F (eds) Operative injury of the common bile duct. Masson, Paris, pp 47–107
48. Alves A, Farges O, Nicolet J, Watrin T, Sauvanet A, Belghiti J (2003) Incidence and consequence of an hepatic artery injury in patients with postcholecystectomy bile duct strictures. Ann Surg 238(1):93–96
49. Holbert BL, Baron RL, Dodd GD 3rd (1996) Hepatic infarction caused by arterial insufficiency: spectrum and evolution of CT findings. Am J Roentgenol 166:815–820
50. Smith GS, Birnbaum BA, Jacobs JE (1998) Hepatic infarction secondary to arterial insufficiency in native livers: CT findings in 10 patients. Radiology 208:223–229
51. Gupta N, Soloman H, Fairchild R, Kaminski DL (1998) Management and outcome of patients with combined bile duct and hepatic artery injuries. Arch Surg 133:176–181
52. Madariaga JR, Dodson SF, Selby R, Todo S, Iwatsuki S, Starzl TE (1994) Corrective treatment and anatomic considerations for

laparoscopic cholecystectomy injuries. J Am Coll Surg 179:321–325
53. Stewart L, Robinson TN, Lee CM, Liu K, Whang K, Way LW (2004) Right hepatic artery injury associated with laparoscopic bile duct injury: incidence, mechanism, and consequences. J Gastrointest Surg 8(5):523–530
54. Li J, Frilling A, Nadalin S, Paul A, Malagò M, Broelsch CE (2008) Management of concomitant hepatic artery injury in patients with iatrogenic major bile duct injury after laparoscopic cholecystectomy. Br J Surg 95(4):460–465
55. Schmidt SC, Settmacher U, Langrehr JM, Neuhaus P (2004) Management and outcome of patients with combined bile duct and hepatic arterial injuries after laparoscopic cholecystectomy. Surgery 135(6):613–618
56. Koffron A, Ferrario M, Parsons W, Nemcek A, Saker M, Abecassis M (2001) Failed primary management of iatrogenic biliary injury: incidence and significance of concomitant hepatic arterial disruption. Surgery 130:722–728
57. Buell JF, Cronin DC, Funaki B, Koffron A, Yoshida A, Lo A, Leef J, Millis JM (2002) Devastating and fatal complications associated with combined vascular and bile duct injuries during cholecystectomy. Arch Surg 137(6):703–708
58. Agarwal AK, Gupta V, Singh S, Agarwal S, Sakhuja P (2008) Management of patients of postcholecystectomy benign biliary stricture complicated by portal hypertension. Am J Surg 195 (4):421–426
59. Perakath B, Sitaram V, Mathew G, Khanduri P (2003) Post-cholecystectomy benign biliary stricture with portal hypertension: is a portosystemic shunt before hepaticojejunostomy necessary? Ann R Coll Surg Engl 85(5):317–320
60. Blumgart LH, Kelley CJ, Benjamin IS (1984) Benign bile duct stricture following cholecystectomy: critical factors in management. Br J Surg 71:836–843
61. Sikora SS, Srikanth G, Agrawal V, Gupta RK, Kumar A, Saxena R, Kapoor VK (2008) Liver histology in benign biliary stricture: fibrosis to cirrhosis. .. and reversal? J Gastroenterol Hepatol 23 (12):1879–1884
62. Way LW, Dunphy JE (1972) Biliary stricture. Am J Surg 124:287–295
63. Jarnagin WR, Blumgart LH (2000) Benign biliary strictures. In: Blumgart LH, Fong Y (eds) Surgery of the liver and biliary tracts, 3rd edn. WB Saunders Company Ltd, London, England, pp 895–933
64. Mercado MA, Domínguez I (2011) Classification and management of bile duct injuries. World J Gastrointest Surg 3(4):43–48
65. Connor S, Garden OJ (2006) Bile duct injury in the era of laparoscopic cholecystectomy. Br J Surg 93:158–168
66. Raute M, Podlech P, Jaschke W, Manegold BC, Trede M, Chir B (1993) Management of bile duct injuries and strictures following cholecystectomy. World J Surg 17:553–562
67. McDonald MI, Farnell MB, Nagorney DM, Ilstrup DM, Kutch JM (1995) Benign biliary strictures: repair and outcome with a contemporary approach. Surgery 118:582–591
68. Pitt HA, Miyamato T, Parapatis SK, Thompkins RK, Longmire WP (1982) Factors influencing outcome in patients with postoperative biliary strictures. Am J Surg 144:14–21
69. Schweizer WP, Matthews JB, Baer HU, Nudelmann LI, Triller J, Halter F et al (1991) Combined surgical and interventional radiological approach for complex benign biliary tract obstruction. Br J Surg 78:559–563
70. Bottger T, Junginger T (1991) Long-term results after surgical treatment of iatrogenic injury of the bile ducts. Eur J Surg 157:477–480
71. Moossa AR, Mayer AD, Stabile B (1990) Iatrogenic injury to the bile duct. Who, how, where? Arch Surg 125:1028–1031
72. Boerma D, Rauws EA, Keulemans YC, Bergman JJ, Obertop H, Huibregtse K et al (2001) Impaired quality of life 5 years after bile duct injury during laparoscopic cholecystectomy: a prospective analysis. Ann Surg 234:750–757
73. Melton GB, Lillemoe KD, Cameron JL, Sauter PA, Coleman J, Yeo CJ (2002) Major bile duct injuries associated with laparoscopic cholecystectomy: effect of surgical repair on quality of life. Ann Surg 235:888–895
74. Sarmiento JM, Farnell MB, Nagorney DM, Hodge DO, Harrington JR (2004) Quality-of-life assessment of surgical reconstruction after laparoscopic cholecystectomy-induced bile duct injuries: what happens at 5 years and beyond? Arch Surg 139:483–489