Review Article

Classification of iatrogenic bile duct injury

Wan-Yee Lau and Eric C.H. Lai

Hong Kong, China

BACKGROUND: **Iatrogenic bile duct injury continues to be an important clinical problem, resulting in serious morbidity, and occasional mortality, to patients. The ease of management, operative risk, and outcome of bile duct injuries vary considerably, and are highly dependent on the type of injury and its location. This article reviews the various classification systems of bile duct injury.**

DATA SOURCES: **A Medline, PubMed database search was performed to identify relevant articles using the keywords "bile duct injury", "cholecystectomy", and "classification". Additional papers were identified by a manual search of the references from the key articles.**

RESULTS: **Traditionally, biliary injuries have been classified using the Bismuth's classification. This classification, which originated from the era of open surgery, is intended to help the surgeons to choose the appropriate technique for the repair, and it has a good correlation with the final outcome after surgical repair. However, the Bismuth's classification does not encompass the whole spectrum of injuries that are possible. Bile duct injury during laparoscopic cholecystectomy tends to be more severe than those with open cholecystectomy. Strasberg's classification made Bismuth's classification much more comprehensive by including various other types of extrahepatic bile duct injuries. Our group, Bergman et al, Neuhaus et al, Csendes et al, and Stewart et al have also proposed other classification systems to complement the Bismuth's classification.**

CONCLUSIONS: **None of the classification system is universally accepted as each has its own limitation. Hopefully, a universally accepted comprehensive classification system will be published in the near future.**

(***Hepatobiliary Pancreat Dis Int 2007; 6: 459-463***)

KEY WORDS: **laparoscopic cholecystectomy; bile duct injury; bile duct stricture; bile leak; classification**

Introduction

Laparoscopic cholecystectomy is now the gold standard for symptomatic cholelithiasis, but it is associated with a higher incidence of bile duct injury than open cholecystectomy. Numerous reports have demonstrated that the incidence of bile duct injuries has risen from 0.1%-0.2% to 0.4%-0.7% from the era of open cholecystectomy to the era of laparoscopic cholecystectomy.[1-3] Bile duct injury following cholecystectomy is an iatrogenic catastrophe associated with significant perioperative morbidity and mortality, reduced long-term survival and quality of life, and high rates of subsequent litigation. Bile duct injury can also occur during other operative procedures. Management depends on the timing of recognition of injury, the extent of bile duct injury, the patient's condition and the availability of experienced hepatobiliary surgeons. Immediate detection and repair are associated with an improved outcome, and the minimum standard of care after recognition of a bile duct injury is immediate referral to a surgeon experienced in bile duct injury repair. The goal of surgical repair of the injured biliary tract is the restoration of a durable bile conduit, and the prevention of short- and long-term complications such as biliary fistula, intra-abdominal abscess, biliary stricture, recurrent cholangitis and secondary biliary cirrhosis.

The ease of management, operative risk, and outcome of bile duct injuries vary considerably and are highly dependent on the type of injury and its location. For this, a classification bearing therapeutic and prognostic implications is needed.

Classification of bile duct injury

Author Affiliations: Department of Surgery, the Chinese University of Hong Kong, Shatin, New Territories, Hong Kong SAR, China (Lau WY and Lai ECH)

Corresponding Author: Wan-Yee Lau, MD, Department of Surgery, the Chinese University of Hong Kong, Prince of Wales Hospital, Shatin, New Territories, Hong Kong SAR, China (Tel: 852-2632 2626; Fax: 852-2637 7974; Email: josephlau@cuhk.edu.hk)

It has long been recognized that strictures involving the common bile duct (CBD) or distal common hepatic duct (CHD) are easier to repair than those with more proximal injuries. In general, the higher the location of injury or stricture, the more difficult is the repair and the greater is the recurrence rate. The Bismuth classification, originated from the era of open surgery, is based on the most distal level at which healthy biliary mucosa at the proximal site of the injury/stricture is available for anastomosis (Table 1, Fig.).[4] The classification is intended to help the surgeon choose the appropriate technique for the repair. This classification has a good correlation with the final outcome after surgical repair.[5] Type 1 strictures can be repaired without opening the left duct and without lowering the hilar plate. Type 2 strictures require opening the left duct for a satisfactory anastomosis. Lowering the hilar plate is not always necessary but may improve the exposure. Type 3 lesions, in which only the ceiling of the biliary confluence is intact, require lowering the hilar plate and anastomosis on the left ductal system. There is no need to open the right duct if the communication between the ducts is wide. With type 4 lesions the biliary confluence is interrupted and requires either reconstruction or two or more anastomoses. Type 5 lesions are strictures of the CHD associated with a stricture on an aberrant right sectorial duct, and the sectorial duct must be included in the repair. McMahon et al[6] suggested that the type of injury may be subdivided into bile duct laceration, bile duct transection or excision, and bile duct stricture. The level of stricture may be further graded according to the Bismuth's classification. McMahon et al also proposed a subdivision into major and minor ductal injury as minor injury can usually be managed by simple suture repair and/or insertion of a T-tube and major injury usually requires hepaticojejunostomy (Table 2).

However, the Bismuth classification does not encompass the whole spectrum of injuries that are possible. Laparoscopic bile duct injury tends to be more severe than those with open cholecystectomy. Several types of laparoscopic injury commonly occur.[7, 8] The classical laparoscopic injury involves the misidentification of the common duct for the cystic duct, with resultant resection of part of the CBD and CHD and associated right hepatic arterial injury. A variant of the classical injury is seen with clip ligation of the CBD with proximal ligation and division of the cystic duct, resulting in biliary obstruction and leakage. A second variant is a simple tenting injury of the CBD. The cystic duct is correctly identified and grasped, and a portion of the CBD is removed between clips simply due to traction. This variant results in obstruction or fistulation. In addition to the main bile duct injuries, cystic duct leakage can occur. Laparoscopic cholecystectomy may

Table 1. Bismuth's classification (1982)[4]

Type	Criteria
1	Low CHD stricture, with a length of the common hepatic duct stump of >2 cm
2	Proximal CHD stricture-hepatic duct stump <2 cm
3	Hilar stricture, no residual CHD, but the hepatic ductal confluence is preserved
4	Hilar stricture, with involvement of confluence and loss of communication between right and left hepatic duct
5	Involvement of aberrant right sectorial hepatic duct alone or with concomitant stricture of the CHD

Table 2. Proposed definition of major and minor bile duct injuries by McMahon et al (1995)[6]

Type of injury	Criteria
Major bile duct injury (at least one of the following present)	Laceration >25% of bile duct diameter Transection of CHD or CBD Development of post-operative bile duct stricture
Minor bile duct injury	Laceration of CBD <25% of diameter Laceration of cystic-CBD junction ("buttonhole tear")

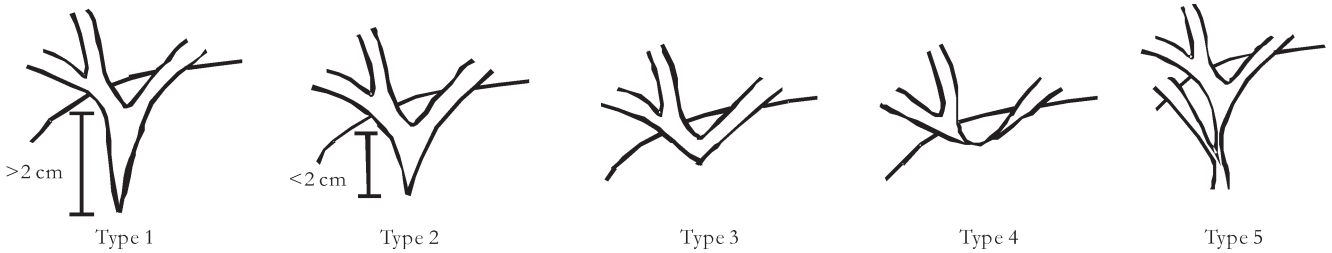

Fig. Diagram illustrating of Bismuth's classification.

Table 3. Strasberg's classification (1995)[9]

Type	Criteria
A	Cystic duct leaks or leaks from small ducts in the liver bed
B	Occlusion of a part of the biliary tree, almost invariably the aberrant right hepatic ducts
C	Transection without ligation of the aberrant right hepatic ducts
D	Lateral injuries to major bile ducts
E	Subdivided as per Bismuth's classification into E1 to E5

Table 4. Amsterdam Academic Medical Center's classification (1996)[10]

Type	Criteria
A	Cystic duct leaks or leakage from aberrant or peripheral hepatic radicles
B	Major bile duct leaks with or without concomitant biliary strictures
C	Bile duct strictures without bile leakage
D	Complete transection of the duct with or without excision of some portion of the biliary tree

Table 5. Neuhaus' classification (2000)[11]

Type	Criteria
A	Peripheral bile leak (in communication with the CBD) A1 Cystic duct leak A2 Bile leak from the liver bed
B	Occlusion of the CBD (or right respectively left hepatic duct, i.e. clip, ligation) B1 Incomplete B2 Complete
C	Lateral injury of the CBD C1 Small lesion (<5 mm) C2 Extended lesion (>5 mm)
D	Transection of the CBD (or right hepatic duct not in communication with the CBD) D1 Without structural defect D2 With structural defect
E	Stenosis of the CBD E1 CBD with short stenosis (<5 mm) E2 CBD with long stenosis (>5 mm) E3 Confluence E4 Right hepatic duct or segmental duct

Table 6. Csendes' classification (2001)[12]

Type	Criteria
I	A small tear of the hepatic duct or right hepatic branch caused by dissection with the hook or scissors during the dissection of Calot's triangle
II	Lesions of the cysticocholedochal junction due to excessive traction, the use of a Dormia catheter, section of the cystic duct very close or at the junction with the CBD, or to a burning of the cysticocholedochal junction by electrocautery
III	A partial or complete section of the CBD
IV	Resection of more than 10 mm of the CBD

Table 7. Stewart-Way's classification of laparoscopic bile duct injuries (2004)[13]

Class	Criteria
I	CBD mistaken for cystic duct, but recognized Cholangiogram incision in cystic duct extend
II	Bleeding, poor visibility Multiple clips placed on CBD/CHD
III	CBD mistaken for cystic duct, not recognized CBD, CHD, or right or left hepatic ducts transected and/or resected
IV	Right hepatic duct (or right sectorial duct) mistaken for cystic duct Right hepatic artery mistaken for cystic artery Right hepatic duct (or right sectorial duct) and right hepatic artery transected

Table 8. Our classification (CUHK, 2007)

Type	Criteria
1	Leaks from cystic duct stump or small ducts in liver bed
2	Partial CBD/CHD wall injuries without (2A) or with (2B) tissue loss
3	CBD/CHD transection without (3A) or with (3B) tissue loss
4	Rt/Lt hepatic duct or sectorial duct injuries without (4A) or with (4B) tissue loss
5	Bile duct injuries associated with vascular injuries

CBD: common bile duct; CHD: common hepatic duct; Rt: right; Lt: left.

be associated with a greater risk of a bile leakage.

Strasberg et al[9] made Bismuth's classification much more comprehensive by including various other types of laparoscopic extrahepatic bile duct injuries. Strasberg's classification of laparoscopic biliary injuries is stratified from type A to type E. Type E injuries are further subdivided into E1 to E5 according to the Bismuth's classification system (Table 3). In order to complement the Bismuth's classification, Bergman et al,[10] Neuhaus et al,[11] Csendes et al,[12] and Stewart et al[13] have also proposed other classification systems to cover the whole spectrum of possible lesions (Tables 4-7).

The outcome of patients with major bile duct injuries combined with arterial disruptions is worse than in patients with an intact blood supply of the bile ducts. None of the early proposed classifications allow for the documentation of an associated vascular

Table 9. Our classification, mechanisms of injury, prevention and treatment

Type	Mechanism of injury	Preventive measures	Treatment for early detection	Treatment for late detection
1	Insecure closure of cystic duct Too deep dissection into gallbladder bed	Attention to operative details	Control bile leak with suturing Laparotomy if required Drain subhepatic space	Drain intraperitoneal collection Control sepsis Endoscopic stenting
2	Incision of CBD instead of cystic duct for operative cholangiogram Clipping of CBD but recognised Laceration of cystic duct/CBD junction Diathermy injury to CBD/CHD	Strasberg's critical view of safety Avoid too much traction on gallbladder Careful use of diathermy	Conversion to laparotomy Repair small laceration Place of T tube controversial Drain subhepatic space If tissue necrosis extensive due to diathermy, treat as Type 3	Early diagnosis without stricture Laparotomy, repair, and drainage Late diagnosis with stricture, treat as Type 3
3	CBD mistaken as cystic duct, with CBD/CHD transected or resected Diathermy injury	Strasberg's critical view of safety Avoid dissection too close to CBD	Conversion to laparotomy Trim divided ducts to healthy tissue Close distal stump HJ to proximal stump Drain subhepatic space	Control sepsis first by draining intraperitoneal collection and proximal bile duct Laparotomy and HJ when sepsis controlled
4	Right HD or sectorial duct mistaken for cystic duct	Recognition of biliary anomaly	Right/left hepatic duct biliary-enteric anastomosis	Asymptomatic: follow up Symptomatic: HJ, liver resection if HJ not possible
5	Right hepatic artery mistaken for cystic artery Diathermy or clip injuries to right hepatic artery during haemostasis	Recognition of vascular anomaly Avoid blind use of diathermy and clip	Reconstruction of vessels and bile ducts if technically possible If not technically possible, ligate duct and vessels and wait and treat as late detection	Asymptomatic with liver atrophy: follow up Symptomatic: HJ±liver resection/ liver transplant

CBD: common bile duct; CHD: common hepatic duct; HD: hepatic duct; HJ: hepaticojejunostomy.

injury. The right hepatic artery lies behind the common hepatic duct at the usual level of transection, and it is vulnerable to injury. Stewart et al[13] proposed a classification system based on the mechanism of the injury (Table 7). They also showed that an associated right hepatic artery injury increased morbidity, and it occurred more often with class Ⅲ and Ⅳ injuries, and less often with class Ⅰ and Ⅱ injuries. In Stewart et al, right hepatic artery injury did not increase the mortality rate or alter the success of biliary repair. However, among biliary injuries repaired by the primary surgeons, right hepatic artery injury was associated with a higher incidence of postoperative abscess, bleeding, hemobilia, hepatic ischemia, and the need for hepatic resection. A similar increase in the complication rate was not seen in patients treated by hepatobiliary surgeons.

To overcome some of the problems associated with the currently available classifications for bile duct injuries, we proposed our own classification (CUHK, 2007) (Table 8). The advantages of this classification are: (a) the degree of injury is in ascending order of severity from type 1 to 5; (b) the mechanisms of injury differ in each type; (c) preventive measures can be instituted for each type to prevent it from happening; (d) the magnitude of treatment differs according to the type of injury (Table 9).

Conclusions

In order to define the type of bile duct injury, several classifications of bile duct injury have been proposed, but none is universally accepted as each of them has its own limitation. Patient's condition, timing of recognition of injury, and the presence of sepsis are not accounted in these classification systems. Among them, Bismuth's classification and Strasberg's classification are most commonly used by clinicians. Hopefully, a universally accepted comprehensive classification system will be seen in the near future.

Funding: None.
Ethical approval: Not needed.
Contributors: LWY proposed the idea, structure, and content of this article. LECH did the literature search and wrote the first draft. LWY also did the revision and final proof read of the article. LWY is the guarantor.
Competing interest: No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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Received May 9, 2007
Accepted after revision June 2, 2007