

## Managing injuries of hepatic duct confluence variants after major hepatobiliary surgery: An algorithmic approach

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### Abstract

**AIM:** To investigate injuries of anatomy variants of hepatic duct confluence during hepatobiliary surgery and their impact on morbidity and mortality of these procedures. An algorithmic approach for the management of these injuries is proposed.

**METHODS:** During a 6-year period 234 patients who had undergone major hepatobiliary surgery were retrospectively reviewed in order to study postoperative bile leakage. Diagnostic workup included endoscopic and magnetic retrograde cholangiopancreatography (E/MRCP), scintigraphy and fistulography.

**RESULTS:** Thirty (12.8%) patients who developed postoperative bile leaks were identified. Endoscopic stenting and percutaneous drainage were successful in 23 patients with bile leaks from the liver cut surface. In the rest seven patients with injuries of hepatic duct confluence, biliary variations were recognized and a stepwise therapeutic approach was considered. Conservative management was successful only in 2 patients. Volume of the liver remnant and functional liver reserve as well as local sepsis were used as criteria for either resection of the corresponding liver segment or construction of a biliary-enteric anastomosis. Two deaths occurred in this group of patients with hepatic duct confluence variants (mortality rate 28.5%).

**CONCLUSION:** Management of major biliary fistulae

that are disconnected from the mainstream of the biliary tree and related to injury of variants of the hepatic duct confluence is extremely challenging. These patients have a grave prognosis and an early surgical procedure has to be considered.

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**Key words:** Biliary aberrations; Bile duct injury; Postoperative bile leakage; Hepatic duct confluence; Hepatectomy

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### INTRODUCTION

Dissection of the biliary tract constitutes the most crucial step in liver resections and every effort should aim to secure integrity and normal bile flow of the liver remnant. However, up to 40% of the patients are lacking the conventional biliary branching pattern and are more often exposed to sectorial bile duct transection during liver resection<sup>[1]</sup>.

The most frequent biliary variants are found in the right liver. The right posterior sectorial duct (RPSD) and the right anterior sectorial duct (RASD) may be joining the left hepatic duct (LHD), the common hepatic duct (CHD) or even the cystic duct<sup>[2-10]</sup>. Although biliary complications in liver resections occur approximately in 10%, they are responsible for one third of the postoperative mortality<sup>[11,12]</sup>. Fortunately, the majority is amenable to non surgical treatment, but when reoperation is necessitated mortality rate may reach up to 70%<sup>[13,14]</sup>. This high

mortality rate is due to the fact that accurate diagnosis is delayed and surgical treatment is influenced by the ongoing intra-abdominal septic process. Our study aims to present our experience in managing injuries of hepatic duct confluence variants proposing an algorithmic approach.

## MATERIALS AND METHODS

During a 6-year period (Jan, 2001-Dec, 2006) 234 patients who underwent major hepatobiliary surgery were retrospectively reviewed, in order to evaluate postoperative biliary complications due to anatomic variations of hepatic duct confluence. The hepatectomy procedures performed included segmentectomy, lobectomy and extended lobectomy (trisegmentectomy). Our technique of hepatectomy has been described previously<sup>[15]</sup>, using the Pringle maneuver, vascular outflow obstruction and sharp parenchymal dissection. For major hepatectomies (lobectomy-extended lobectomy) hilar dissection was performed to divide the correspondent vessels<sup>[16]</sup>. The diagnosis of a biliary complication was based upon the presence of a persistent bile leakage *via* the drain, the surgical incision, or the development of an intra-abdominal biloma confirmed by imaging studies. In our department, we do not perform routine preoperative imaging studies of the biliary tree anatomy. Postoperative diagnostic imaging studies included endoscopic retrograde and magnetic resonance cholangiopancreatography (ERCP-MRCP) and occasionally scintigraphy (Tc99m-HIDA) or fistulography.

Thirty patients (12.8%) who developed postoperative bile leaks were identified and conservative treatment (endoscopic stenting and percutaneous drainage) resolved the problem in 23 patients. In the remaining 7 patients, a biliary variant injury of hepatic duct confluence was diagnosed. One of these seven patients underwent an initial laparoscopic cholecystectomy and was also included in this group.

Clinical characteristics, type of operation performed, type of biliary variant, treatment and outcome of these patients with variant injuries are presented in Table 1. Classification of bile duct injuries was based on that used for hepatic duct confluence by Ayuso *et al*<sup>[17]</sup>. Treatment involved a conservative (percutaneous drainage of bilomas and perihepatic abscesses, antibiotics, *etc*) and a surgical (liver resection, biliary-enteric anastomosis) approach. Timing of surgical intervention was based upon criteria of non-responsiveness to external drainage and/or persistence of intra-abdominal sepsis. The type of procedure was based upon the estimated volume of the liver remnant and the functional reserve of the liver (Child-Pugh classification) and intraoperative factors (local inflammatory process, aberrant bile duct features, *etc*).

## RESULTS

Injuries of variants of the hepatic duct confluence were retrospectively found in 7 patients (three males and four females) with an age range from 36 to 76 years old. Six patients had undergone initially major liver resections (2 for hydatid cyst and 4 for carcinoma) and in one patient a laparoscopic cholecystectomy was performed. All

patients developed a major biliary fistula postoperatively that was disconnected from the mainstream of the biliary tree. According to the classification and imaging workup previously mentioned, 1 type C, 3 type D, 2 type E and 1 type F injuries were recognized. This simply means that the most common injury involved the right posterior sectorial duct (RPSD) in four patients (cases 1, 2, 6 and 7), while injuries of the right anterior sectorial duct (RASD) were recognized in two patients (cases 3 and 4; Figure 1). In one patient (case 5), during an extended right lobectomy, the sectorial bile duct draining liver segment I, joining separately the common bile duct (type E injury), was transected with a consequent biliary fistula (Figure 2).

All patients were initially treated conservatively, but only two (cases 3 and 4) had an uneventful outcome with resolution of the bile leak 2 mo and 4 mo, respectively, after the initial operation. One patient (case 2) refused surgical therapy and died from septic shock. The remaining four patients were approached surgically; two underwent a delayed biliary-enteric (B-E) anastomosis (cases 1 and 7) while the other two had a resection of the compromised liver segments (cases 5 and 6).

In case 1, 14 mo after the initial procedure (left lateral sectionectomy) exploratory laparotomy revealed a complex situation; liver segment's IV duct was found transected and draining in the abdomen and the RPSD was ligated near its junction with the LHD. Resection of segment IV and B-E anastomosis of the dilated RPSD with a Roux-en-Y intestinal loop were carried out and the patient had an uneventful postoperative course. In contrast, the delayed B-E anastomosis in case 7, performed 10 mo after the initial procedure (laparoscopic cholecystectomy), failed and resection of liver segments VI & VII was carried out. Unfortunately, the postoperative course was complicated by overwhelming sepsis due to accidental injury of the duodenum and the patient died.

The last 2 patients (cases 5 and 6) underwent liver resections of the compromised liver segments, 6 mo and 8 mo, respectively, after initial operation with an uneventful postoperative course. An algorithmic approach for these injuries is depicted in Figure 3.

Overall, hospital stay ranged from 20-150 d (mean, 63 d) and the mortality rate in this group of patients with injuries of variants of the hepatic duct confluence was 28.5% (2/7).

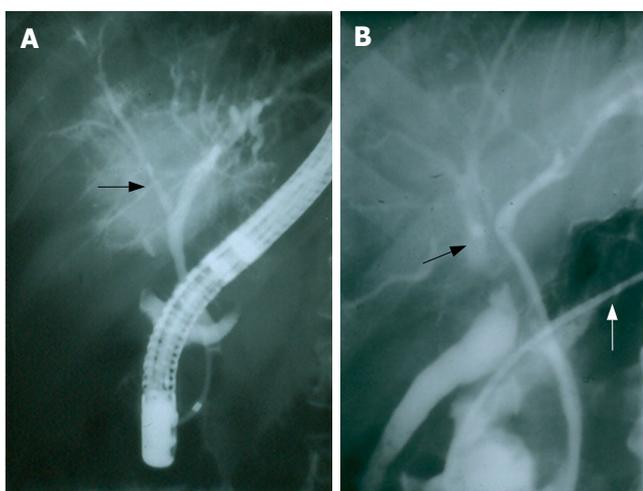
## DISCUSSION

Prevailing strategy in hepatobiliary surgery should always be the ascertainment of the integrity of normal bile flow from the liver remnant; otherwise, life-threatening complications may occur. Biliary complications in hepatobiliary surgery vary between 3%-15% and share a significant portion of the postoperative morbidity and mortality<sup>[11-14,18]</sup>. The cause of biliary leakage is usually due to unsutured collateral biliary branches of the cut surface and a non-surgical treatment settles the problem in the majority of the patients<sup>[19]</sup>. However, aberrant biliary anatomy is frequently encountered during hepatobiliary surgery and represents a totally different problem from that aforementioned.

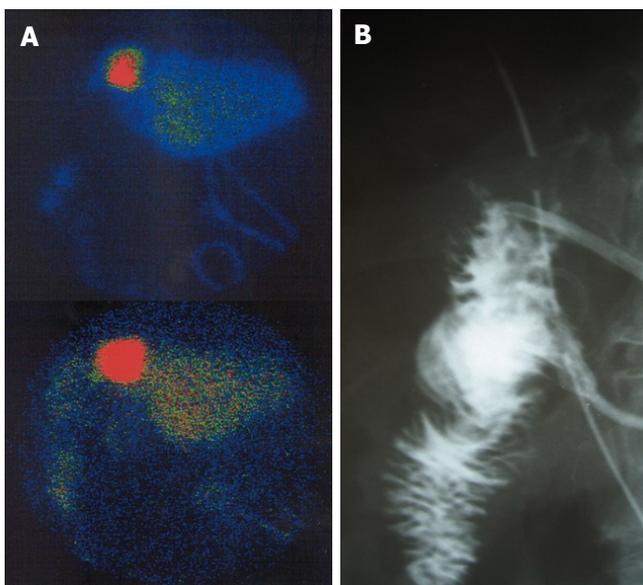
**Table 1** Characteristics of patients with injury of aberrant bile ducts

No	Sex	Age	Initial operation	Biliary variant injury <sup>1</sup>	Treatment	Outcome
1	F	51	Left lateral sectionectomy (Hydatid cyst)	RPSD (type D)	Resection of segment IV and biliary-enteric (B-E) anastomosis	Uneventful
2	F	76	Left Hepatectomy (CHD carcinoma)	RPSD (type C)	Denied liver resection	Died
3	M	65	Left hepatectomy (Liver carcinoma)	RASD (type D)	Conservative (external drainage)	Resolved after 2 mo
4	M	71	Left hepatectomy (Liver carcinoma)	RASD (type D)	Conservative (external drainage)	Resolved after 4 mo
5	M	51	Right extended lobectomy (cholangiocarcinoma)	Segment's I duct (type E)	Resection of segment I	Uneventful
6	F	49	Resection of segment V (Hydatid cyst)	RPSD (type E)	Liver resection (VI, VII)	Uneventful
7	F	36	Laparoscopic cholecystectomy	RPSD (type F)	1. B-E anastomosis failed 2. Liver resection (VI, VII)	Died

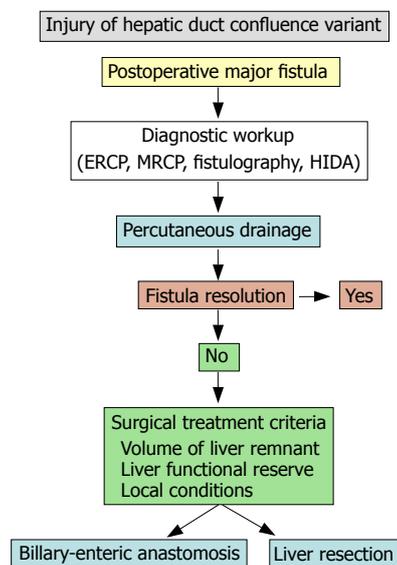
<sup>1</sup>Types of biliary variants<sup>[17]</sup>: Type A: Right hepatic duct (RHD) joins the left hepatic duct (LHD); Type B: Triple confluence of right posterior sectorial duct (RPSD) and right anterior sectorial duct (RASD) and LHD; Type C: RASD or the RPSD joins the common bile duct (CBD); Type D: RASD or RPSD joins separately the LHD; Type E: Absence of confluence; sectorial ducts join separately at the common hepatic duct (CHD); Type F: RPSD joins the cystic duct.



**Figure 1** A: Retrograde cholangiogram demonstrating the left hepatic duct and its confluence with the right anterior sectorial duct (arrow, case 7); B: Fistulogram via the drain tube resulted in a retrograde cholangiogram through the transected right posterior sectorial duct (black arrow). Presence of a nasobiliary tube (white arrow) draining the left hepatic duct (case 7).



**Figure 2** A: HIDA scan demonstrating bile leakage after right extended hepatectomy (case 5); B: Stentogram with intact hepatico-jejunal anastomosis in the same patient (case 5).



**Figure 3** An algorithmic approach for the management of patients with injuries of hepatic duct confluence variants.

Preoperative assessment of biliary anatomy and possible variations in order to prevent intraoperative injury is currently performed by means of three dimensional helical computed tomography cholangiography<sup>[20-23]</sup> and various magnetic resonance imaging techniques<sup>[24-27]</sup>. If a biliary variant is assumed to be injured intraoperatively, the surgeon should perform an intraoperative cholangiography through the injured bile duct in order to estimate the type and extent of injury. In case of a disconnected from the biliary tree sectorial bile duct the decision of the surgical approach should be based on criteria of the volume of the liver remnant and liver functional reserve in case of additional hepatectomy; otherwise a Roux-en-Y biliary-enteric anastomosis must be carried out in order to drain bile to the gut.

Several efforts have been made in order to reduce or manage postoperative bile leaks. A randomized trial using an intraoperative leakage test, injecting isotonic sodium chloride solution *via* the cystic duct had no advantage on reducing postoperative bile leak<sup>[28]</sup>, while the application of a fibrin glue sealant on the cut surface of the liver seems not to be justified<sup>[29]</sup>. A case report describing infusion

of pure ethanol in an injured sectorial duct resulting in atrophy of the corresponding liver segment and cessation of postoperative bile leak seems to be a minimally invasive approach to this devastating complication needing, however, further evaluation<sup>[30]</sup>. Postoperative persistent major biliary fistula that has been attributed from diagnostic workup to an injury of a variant of the hepatic duct confluence is initially treated conservatively by means of percutaneous drainage and management of ensuing sepsis usually in a critical care environment. This approach was effective in two of our seven patients and the bile leak resolved 2 mo and 4 mo after initial operation.

Unfortunately, conservative treatment may not settle the problem and ongoing intra-abdominal sepsis fuelled by the major bile leak is associated with high morbidity and mortality. Despite adequate biliary drainage and critical care support, surgical treatment should be instituted in order to manage this problem. A planned approach based upon patient's general status, volume of future liver remnant and liver functional reserve, type and extent of injury and the volume of the corresponding liver segment draining through the injured sectorial bile duct are crucial for decision making. Surgical treatment includes either a resection of the corresponding liver segment or a biliary-enteric anastomosis with a Roux-en-Y limb. In our series, two patients underwent a biliary-enteric anastomosis, which was not successful in one of them and resection of the corresponding liver segment was additionally carried out. Resection of the liver segment, drained by the injured sectorial bile duct, was carried out successfully in two more patients. Therefore, in the case of injury of a variant of the hepatic duct confluence an algorithmic approach is proposed and depicted schematically in Figure 3.

In conclusion, variants of hepatic duct confluence are frequently involved and injured during major hepatic surgery and seriously complicate postoperatively all patients due to delay of diagnosis and ongoing intra-abdominal sepsis. Preoperative imaging of the biliary branching pattern (ERCP, MRCP) remains the only way to recognize and address properly the problem posed by the variant of biliary anatomy. MRCP offers a reliable and non-invasive visualization of the biliary tree in a manner for the surgical approach to be planned and adapted to prevent an injury of a variant of the hepatic duct confluence. However, if this occurs, conservative treatment is the initial approach in managing these patients. Failure to resolve the problem conservatively leads to a planned re-operation which includes either a biliary-enteric anastomosis or a resection of the corresponding to the injury liver segment.

## COMMENTS

### Background

Hepatobiliary surgery is frequently encountered with variations in biliary anatomy. Injuries of variants of the hepatic duct confluence add significant morbidity and mortality after liver resections, due to the development of major bile leakage and ensuing septic sequelae.

### Research frontiers

Preoperative evaluation of anatomical variants seems to be critical in avoiding inadvertent injury. Conservative treatment by means of minimally invasive techniques of injuries of variants of hilar biliary anatomy requires further

evaluation. Surgical treatment is still debatable whether to resect the compromised liver segment or to restore bile drainage to the gut by performing a biliary-enteric anastomosis.

### Innovations and breakthroughs

The proposal of an algorithmic approach to manage postoperatively the injuries of the variants of hepatic duct confluence.

### Applications

The implications of this study are for further evaluation of newer conservative therapeutic techniques and/or decision-making regarding surgical management.

### Peer review

The author's proposed an algorithm to manage the injury of the biliary tract after hepatobiliary surgery. Their recommendation is of clinical value for the patients who may have biliary anomaly. However, it is most important for avoiding bile duct injuries during hepatic resection to evaluate accurate anatomy of bile duct preoperatively.

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