Devastating and Fatal Complications Associated With Combined Vascular and Bile Duct Injuries During Cholecystectomy

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Hypothesis: Multiple centers have reported on bile duct injuries after cholecystectomy, but few have reported on the impact of concomitant vascular injuries.

Design: Twenty-seven life-threatening complex injuries (CIs) (Bismuth level III, IV, or V or combined arterial-ductal injuries) were retrospectively compared with 22 noncomplex injuries (NCs) (level I or II).

Setting: Tertiary referral center.

Main Outcome Measures: The incidence and level of biliary and arterial injuries and their resulting morbidity and mortality.

Results: Bismuth classifications of all injuries were as follows: level I in 6 patients (12%), II in 19 (39%), III in 12 (24%), IV in 8 (16%), and V in 4 (8%). Diagnosis was based on peritonitis (n=13 [27%]), endoscopic retrograde cholangiography (n=7 [14%]), and percutaneous transhepatic cholangiography (n=7 [14%]). Delayed referral was more common in levels I through IV (100 days) than in level V (15 days) (P<.001). Repairs were attempted in level IV (75%), III (67%), V (25%), and II (11%). Thirteen arterial injuries (26%) occurred irrespective of ductal injury level: I (n=1), II (n=3), III (n=1), IV (n=5), and V (n=3). There was, however, a higher incidence of repairs before referral in the CI group (59% vs 5%; P<.01), with resulting higher rates of complication (70% vs 23%; P<.01). Five deaths occurred in the CI group vs 1 in the NC group (P=.14). In univariate analysis, the presence of arterial injury vs no arterial injury was a predictor of mortality (5 [38%] of 13 patients vs 1 [3%] of 36 patients; P<.001).

Conclusion: Bile duct injuries after cholecystectomy can be morbid and lethal with the incidence of arterial injury grossly underestimated.

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Bile duct injuries are the most dreaded complication associated with either open or laparoscopic cholecystectomy. Initial experiences with laparoscopic cholecystectomy noted a dramatic rise in iatrogenic bile duct injuries.1,2 This rise was first attributed to a significant learning curve. Despite the widespread application of the laparoscopic procedure, the incidence of iatrogenic injury has not declined. Instead, it has stabilized at a level higher than that experienced in open cholecystectomy.3 With recognition of this phenomenon, multiple series have been reported with incidence and management strategies for bile duct injuries. However, few groups have documented the incidence or clinical impact of combined vascular and biliary injuries in either open or laparoscopic cholecystectomy.1,3

Recently, the clinical importance of bile duct ischemia after duct-to-duct or biliary enteric anastomosis has become the central focus in liver transplantation. Increased frequency of right lobe liver transplantation from living related donors has resulted in an increased focus on the microvascular distribution of the biliary confluence. Ductal vasculature is such that the lower duct receives its blood supply by means of coaxial distribution, whereas the confluence and intrahepatic ducts are supplied by retrograde flow through intrahepatic segmental arterial branches. Early experiences in segmental graft transplantation were met with a higher incidence of bile duct complications resulting from what was thought to be local disruption of the ductal coaxial collateral flow during donor duct mobilization, which resulted in ductal stricture or disruption.

Despite the abundance of literature1,4,5,9,10 describing the incidence of bile duct injuries during open and laparoscopic cholecystectomy, little has been mentioned regarding the occurrence of...
PATIENTS, MATERIALS, AND METHODS

Medical records were reviewed on 49 consecutive patients with iatrogenic bile duct injuries from either open or laparoscopic cholecystectomy who were treated at the University of Chicago between January 1, 1986, and December 31, 2000.

The medical records were examined for patient demographics and preoperative and postoperative clinical scenarios, which included symptoms, operative procedures, diagnostic methods, operative repairs, length of intensive care unit and hospital stays, postoperative follow-up, short- and long-term complications, need for radiographic or operative revision, and patient mortality.

Multiple diagnostic methods were used to define biliary injuries, including surgical recognition, endoscopic retrograde pancreatography and percutaneous transhepatic cholangiography (PTC), and hepatobiliary excretion scintigraphy. Arterial injuries were identified intraoperatively or defined by hepatic arteriograms. Primary management, defined as all therapeutic interventions performed after recognition of bile duct injuries, included surgical intervention, endoscopic or percutaneous transhepatic dilation, and stenting. Failed interventions were defined by either biliary obstruction or recurrent cholangitis associated with a radiographically defined biliary sticture. The interval from diagnosis to definitive repair was defined as the number of days from initial injury to attempted definitive repair at the University of Chicago. This interval was inclusive of any previous repairs performed at outside medical centers.

Biliary strictures were classified using Bismuth levels of bile duct injuries: Bismuth level I, low common hepatic duct stricture (stump >2 cm); level II, common hepatic duct less than 2 cm; level III, no common hepatic duct with an intact hepatic duct confluence intact; level IV, destruction of the hepatic duct confluence; and level V, aberrant right sectorial duct alone or in conjunction with the common duct.

Surgical management involved identification of the common hepatic duct either at the proximal common hepatic duct or at the level of the hepatic duct confluence. All fibrotic material was excised, and either a single or multiple biliary-enteric anastomosis was performed using 5-0 absorbable monofilament sutures. All anastomoses were stented using either retrograde stent placement or preplaced transhepatic catheters. The catheters were studied postoperatively by cholangiography to confirm intact biliary-enteric anastomoses. The stents were later removed. All patients were followed as outpatients. Management failures were defined as patients requiring further invasive procedures to correct either biliary obstruction or recurrent episodes of cholangitis. Once identified, these patients were studied by PTC, and, when applicable, angioplasty or stenting was implemented. Surgical revision was reserved for radiologic treatment failures.

All data are presented as mean ±SD. Statistical analyses were performed using the t test (2-tailed, unpaired) and χ² analysis. Statistical significance was set at P<.05.

combined vascular and bile duct injuries. The first large series, 10 which retrospectively examined the sequelae of combined “vasculobiliary” injuries, identified arterial injuries in patients with failed biliary-enteric repairs after iatrogenic bile duct injuries. This study 10 also noted an association between the incidence of arterial injury and the Bismuth level of the ductal injury. In a similar study by Gupta et al, 7 a high incidence of hepatic necrosis or abscess after cholecystectomy and related general surgical intervention was associated with concomitant hepatic arterial injuries.

This study examines our experience with all iatrogenic bile duct injuries referred to the University of Chicago for definitive management. The principal analysis examines the correlation between arterial injuries and Bismuth level and evaluates the impact of their relationship on patient morbidity and mortality rates. In addition, the level of arterial injury and the incidence of previous attempts at surgical repair were examined for their impact on postoperative morbidity and mortality rates.

RESULTS

Forty-nine consecutive patients with iatrogenic bile duct injuries were examined and divided into 2 groups for comparison. The first group had complex injuries (CIs) (n=27), defined as Bismuth level III, IV, or V or any Bismuth level injury with concurrent arterial injuries. The second group had noncomplex injuries (NCIs) (n=22), defined as Bismuth level I or II without vascular injuries. Six patients (12%) were referred internally, and the remaining were transferred from outside hospitals. Female sex was predominant in the overall series (27 [55%] of 49 patients), whereas a male predominance was noted in level II and V injuries (Table 1). The CI group had a 2:1 female predominance and the NC group had a 0.7:1 female predominance (Table 2). Biliary duct injuries by level were evenly distributed: I, 6 patients (12%); II, 19 (39%); III, 12 (24%); IV, 8 (16%); and V, 4 (8%). The mean patient ages for all Bismuth levels were similar (43.7-50.6 years), with an overall range of 18 to 88 years. The mean age of patients in the CI group was 49.4±16.5 years (range, 26-88 years) and in the NC group was 47.1±15.2 years (range, 18-68 years). Cholecystitis was a common cause of bile duct injury (31 [63%] of 49 patients) and was evenly distributed among all Bismuth level injuries. When CI and NC patients were compared, there was no difference in cholecystitis rates (Table 2). Nine patients (18%) included in this study incurred bile duct injuries during open cholecystectomy. The levels of injury incurred during the open procedure were evenly distributed, except in the lower ductal injuries: 6 patients in level II (50%) and 1 each (11%) in levels III, IV, and V. After an initial laparoscopic attempt, conversion to the open procedure occurred in 10 cases (26%). A lower incidence of conversion from a laparoscopic to an open procedure was observed among patients with resulting CIs (4 [17%] of 24 patients) or vascular injuries (2 [15%] of 13 patients).

The diagnosis of bile duct injury was based on peritonitis in 13 patients (27%), endoscopic retrograde pancrea-
tography in 19 (39%), and PTC in 7 (14%). Delayed referral was more common in levels I through IV (100 days) than in level V (15 days) \((P=.003)\).

Time from injury to referral was 142.9 ± 175.6 days in the NC group and 53.3 ± 155.8 days in the CI group \((P=.07)\) (Table 3). Repairs were attempted in levels II \((n=1)\), III \((n=8)\), IV \((n=6)\), and V \((n=1)\). One repair (5%) was attempted in the NC group, with a duct-to-duct anastomosis performed at the level of the injury. A higher incidence of repairs occurred before referral in the CI group \((16 [59%] of 27 patients vs 1 [5%] of 22 patients; \(P<.01)\). Twenty therapeutic attempts were made in 16 patients in the CI group, including hepaticejejunostomy \((n=5)\), duct-to-duct anastomosis \((n=7)\), and T-tube \((n=4)\) and PTC catheter placement \((n=4)\).

Arterial injuries \((n=13 [26%])\) were most predominant among the higher Bismuth levels: I, 1 patient (17%); II, 3 (11%); III, 1 (8%); IV, 5 (63%); and V, 3 (75%). The right hepatic artery was injured in 10 patients and the main hepatic artery was injured in 3 patients (Figure 1 and Figure 2). In univariate analysis, arterial injury vs no arterial injury was a predictor of mortality \((5 [38%] of 13 patients vs 1 [3%] of 36 patients; \(P<.001)\), whereas multivariate analysis did not identify arterial injury as an independent predictor of survival. Definitive operations varied according to the level of injury. In the NC group, the following procedures were performed: hepaticejejunostomy \((n=8)\), choledochojejunostomy \((n=5)\), PTC angioplasty \((n=6)\), and primary repair \((n=3)\). In the CI group, procedures included hepaticejejunostomy \((n=16)\),

**Table 1. Demographic Characteristics of 49 Patients With Iatrogenic Bile Duct Injuries After Cholecystectomy**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Bismuth Level</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>I ((n=6))</td>
<td>II ((n=19))</td>
<td>III ((n=12))</td>
<td>IV ((n=8))</td>
<td>V ((n=4))</td>
</tr>
<tr>
<td>Age, mean ± SD, y</td>
<td>43.7 ± 20.9</td>
<td>49.0 ± 12.9</td>
<td>47.8 ± 15.6</td>
<td>50.4 ± 16.3</td>
<td>50.6 ± 26.1</td>
</tr>
<tr>
<td>Sex, M/F</td>
<td>1:2.0</td>
<td>1:1.0</td>
<td>1:3.0</td>
<td>1:1.7</td>
<td>1:0.3</td>
</tr>
<tr>
<td>Cholecystitis, No. (%)</td>
<td>3 (50)</td>
<td>13 (68)</td>
<td>6 (50)</td>
<td>6 (75)</td>
<td>3 (75)</td>
</tr>
<tr>
<td>Laparoscopy, No. (%)</td>
<td>6 (100)</td>
<td>13 (68)</td>
<td>11 (92)</td>
<td>7 (88)</td>
<td>3 (75)</td>
</tr>
<tr>
<td>Outside referral, No. (%)</td>
<td>6 (100)</td>
<td>15 (79)</td>
<td>11 (92)</td>
<td>7 (88)</td>
<td>4 (100)</td>
</tr>
</tbody>
</table>

**Table 2. Comparison of Demographic Characteristics by Group**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>NC Group ((n=22))</th>
<th>CI Group ((n=27))</th>
<th>(P) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, mean ± SD, y</td>
<td>47.1 ± 15.2</td>
<td>49.4 ± 16.5</td>
<td>.15</td>
</tr>
<tr>
<td>Male, No. (%)</td>
<td>13 (59)</td>
<td>9 (33)</td>
<td>&lt;.07</td>
</tr>
<tr>
<td>Cholecystitis, No. (%)</td>
<td>16 (68)</td>
<td>15 (52)</td>
<td>.21</td>
</tr>
<tr>
<td>Laparoscopy, No. (%)</td>
<td>19 (86)</td>
<td>21 (78)</td>
<td>.44</td>
</tr>
</tbody>
</table>

\*NC indicates noncomplex injury; CI, complex injury.

**Table 3. Clinical Presentation of the Patient Groups**

<table>
<thead>
<tr>
<th>Presentation Characteristic</th>
<th>NC Group ((n=22))</th>
<th>CI Group ((n=27))</th>
<th>(P) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to referral, mean ± SD, d</td>
<td>142.9 ± 175.6</td>
<td>53.3 ± 155.8</td>
<td>&lt;.07</td>
</tr>
<tr>
<td>Attempts at repair, No. (%)†</td>
<td>1 (5)</td>
<td>20 (74)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Arterial injury, No. (%)</td>
<td>0 (0)</td>
<td>13 (48)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Complications, No. (%)</td>
<td>5 (23)</td>
<td>19 (70)</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

\*NC indicates noncomplex injury; CI, complex injury.

†These are surgical repairs before referral.

Figure 1. A, Computed tomographic scan demonstrating segmental necrosis after a laparoscopic cholecystectomy. B, Percutaneous transhepatic cholangiogram demonstrating a transected right hepatic duct. C, Aortic angiogram demonstrating a transected right hepatic artery.

Figure 2. A, Accessed duct for PTC (Post-RT). B, Cystic duct. C, CBD. Access to Duct for PTC (Post-RT).
hepatic lobectomy (n=1), hepatic lobectomy and hepaticojejunostomy (n=3), liver transplantation (n=1), choledochojunctionostomy (n=2), PTC angioplasty (n=3), and primary repair (n=1). One additional patient in the CI group died while awaiting liver transplantation.

Complications were seen more frequently in the CI group vs the NC group (19 [70%] of 27 patients vs 5 [23%] of 22 patients; P<.01). The complications incurred in the NC group were sepsis (n=2), recurrent cholangitis (n=2), and wound infection (n=1). One patient died of sepsis in the NC group. In the CI group, the complications included sepsis (n=8), wound infection (n=4), intra-abdominal abscess (n=2), recurrent cholangitis (n=2), hepatic abscess (n=1), prolonged ileus (n=1), cardiac dysrhythmia (n=1), and prolonged ventilation (n=1). A greater incidence of postrepair complications in the CI group led to longer lengths of stay in the intensive care unit (8.0±15.1 vs 0.2±0.7 days; P<.01) and in the hospital overall (20.2±22.1 vs 6.0±1.0 days; P<.01). Five deaths (19%) occurred in the CI group vs 1 (5%) in the NC group (P=.14). All deaths were due to progressive biliary and hepatic sepsis resulting in multisystem organ failure. The 9 recurrences (18%; median, 12 months) were evenly distributed between the CI and NC groups. Four recurrences (18%) were observed in the NC group and were repaired by left hepatic duct hepaticojejunostomy (n=1) or PTC balloon angioplasty (n=3). Five recurrences (19%) were observed in the CI group and were repaired by confluence hepaticojejunostomy (n=3) or PTC balloon angioplasty (n=2). The interval from repair to recurrent stricture was shorter in the CI group but was not significant (11.8±2.0 vs 35.0±35.5 months; P=.12).

Each year, more than 500,000 laparoscopic cholecystectomies are performed in the United States. Early after the inception of laparoscopic cholecystectomy, the incidence of iatrogenic bile duct injuries dramatically rose.1,2 With the wide application of laparoscopic cholecystectomy, the incidence of these injuries stabilized at 1.3%, which is still significantly higher than the 0.6% incidence observed during the open cholecystectomy era.13 The resulting literature14-23 describing the mechanism, incidence, and method of repair of iatrogenic biliary injuries has been almost as prolific as the injury itself. Few researchers,9-12 however, have addressed either the existence or the incidence and sequelae of combined arterial and biliary injuries.

Only recently has a large series10 examined the incidence of vasculobiliary injuries and their association with the Bismuth level of injury. In this series from Northwestern University Medical School, 11 of 18 patients were identified as having concomitant arterial and biliary injuries after failed primary bile duct injury repairs. The incidence of arterial injury in this series was 63% at Bismuth level III and 71% at level IV. A lower incidence (33%) of arterial injury was observed when the bile duct injury was at Bismuth level II. In the Northwestern se-
In a smaller series, from the St Louis University group, 7,10 of 13 patients were identified with concurrent iatrogenic hepatic artery and bile duct injuries. Similar to the Northwestern series, the St Louis group identified a significant incidence of hepatic necrosis or abscess formation in 3 of the 4 patients with concomitant arterial injury. Two of the 3 patients had significant necrosis requiring further surgical revision or drainage. Aside from these series, the literature provides little insight into the actual incidence or clinical impact of combined vascular and biliary injuries. Aside from these series, the literature provides little insight into the actual incidence or clinical impact of combined vascular and biliary injuries, except for the occasional mention of their existence.

The present series noted several similarities with the Northwestern10 and St Louis’ series. Thirteen patients were identified in our study with concomitant arterial and biliary duct injuries, for an overall incidence of 27%. This is a staggering number considering the limited literature present on the incidence or sequelae of such injuries. Similar to the Northwestern series, there was a close association between the incidence of arterial injuries and higher Bismuth level injuries. In our experience, there was a 75% incidence of arterial injury at Bismuth level V, 63% at level IV, and 8% at level III. The principal arterial injury noted in all series was either complete division or significant stenosis of the right hepatic artery in isolation. 7,10 In the present series, transection of the right hepatic artery was the predominant arterial injury (10 [77%] of 13 patients), with variable clinical outcomes ranging from no apparent sequelae to multisystem organ failure. The 3 patients with complete transaction of the common hepatic artery fared worse, with 2 dying of multisystem organ failure and the third requiring orthotopic liver transplantation. (Table 4).

Univariate analysis demonstrated that arterial injury was predictive of patient mortality, but it was not significant when examined by multivariate analysis examining arterial injury in combination with the Bismuth level. The clinical importance of normal hepatic artery flow in biliary surgery is further highlighted by the overall complication rate incurred in the Northwestern, 10 St Louis, 7 and Switzerland 8 series. These varied from hepatic insufficiency to hepatic abscess and late biliary-enteric strictures. The Switzerland study 8 included patients who acquired hepatic artery transections during Whipple procedures and underscores the variability of clinical outcomes from no sequela to necessitating major biliary revisions. This is consistent with our clinical findings, with 3 patients developing hepatic abscesses and 5 experiencing recurrent biliary sepsis. Thus, combined hepatic artery and bile duct injury seems to be a significant indicator of patient morbidity and mortality, although their clinical manifestations and severity are variable. This study differs from the others by identifying a similar incidence of recurrent stricture after definitive repair between the groups with and without arterial injuries. A shorter interval from repair to recurrent stricture was identified when a concurrent arterial injury was present.

Similar to the Northwestern10 series, an increased incidence of arterial injury was observed in higher Bismuth level injuries in our study. With the observation that most failed biliary-enteric anastomoses were associated with previously unrecognized concomitant hepatic artery injuries, we recommend that preoperative hepatic angiograms be performed selectively. Patients with Bismuth level IV and V injuries identified during their initial evaluations or patients with failed primary biliary-enteric repairs should be included in the group of patients approached with preoperative angiography. Most combined vascular and biliary injuries seem to select themselves, with a shorter interval from injury to presentation. The shortest interval was noted in the combined injury group (8.5 days), followed by the CI group (53.2 days) and the NC group (142.9 days). Whether identified prospectively or intraoperatively, the management of bile duct injuries should be based on the residual and collateral vasculature of the liver. In instances of an isolated right hepatic injury, the right lobe can often receive collateral flow from the left lobe in up to 30% of cases, whereas in the remainder of cases, significant necrosis can result. 1,8,10 This is often a difficult decision considering the lessons learned from transplantation, where early hepatic artery thrombosis could result in minimal adverse effects to total graft failure from biliary necrosis. The extent of hepatic or biliary necrosis can often be accentuated by concurrent portal circulation injury.

### Table 4. Outcomes in 13 Patients After Arterial Injuries*

<table>
<thead>
<tr>
<th>Hepatic Artery Injured</th>
<th>Previous Repair</th>
<th>Complications</th>
<th>Surgery</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Right</td>
<td>None</td>
<td>Abscess</td>
<td>PTC</td>
<td>Alive</td>
</tr>
<tr>
<td>Right</td>
<td>None</td>
<td>Abscess</td>
<td>Lobectomy</td>
<td>Alive</td>
</tr>
<tr>
<td>Right</td>
<td>None</td>
<td>Wound infection</td>
<td>CDJ</td>
<td>Alive</td>
</tr>
<tr>
<td>Right</td>
<td>Duct-duct</td>
<td>SVT</td>
<td>Hepaticojejunostomy</td>
<td>Alive</td>
</tr>
<tr>
<td>Right</td>
<td>Hepaticojejunostomy</td>
<td>None</td>
<td>Hepaticojejunostomy</td>
<td>Alive</td>
</tr>
<tr>
<td>Right</td>
<td>Hepaticojejunostomy</td>
<td>Wound infection</td>
<td>Hepaticojejunostomy</td>
<td>Alive</td>
</tr>
<tr>
<td>Right</td>
<td>Hepaticojejunostomy</td>
<td>Wound injection</td>
<td>Hepaticojejunostomy</td>
<td>Alive</td>
</tr>
<tr>
<td>Right</td>
<td>Duct-duct</td>
<td>Sepsis</td>
<td>Lobectomy</td>
<td>Dead</td>
</tr>
<tr>
<td>Right</td>
<td>Duct-duct</td>
<td>ARDS</td>
<td>Hepaticojejunostomy</td>
<td>Dead</td>
</tr>
<tr>
<td>Right</td>
<td>None</td>
<td>Sepsis</td>
<td>CDJ</td>
<td>Dead</td>
</tr>
<tr>
<td>Common</td>
<td>None</td>
<td>Sepsis</td>
<td>PTC</td>
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<td>Common</td>
<td>None</td>
<td>Sepsis</td>
<td>Lobectomy</td>
<td>Dead</td>
</tr>
<tr>
<td>Common</td>
<td>Hepaticojejunostomy</td>
<td>Sepsis</td>
<td>OLT</td>
<td>Alive</td>
</tr>
<tr>
<td>Common</td>
<td>Hepaticojejunostomy</td>
<td>Sepsis</td>
<td>CDJ</td>
<td>Alive</td>
</tr>
</tbody>
</table>

*PTC indicates percutaneous transhepatic cholangiography; CDJ, choledochojejunostomy; SVT, supraventricular tachycardia; ARDS, adult respiratory distress syndrome; and OLT, orthotopic liver transplantation.
Significant hepatic compromise may necessitate that hepatic lobectomy be contemplated as a surgical option. This study also identified that previous attempts at surgical repairs were significantly more common in the CI group (15 [56%] of 27 patients) compared with the NC group (1 [5%] of 22 patients). A higher incidence of hepatic artery injury was also identified in patients with previous surgical repairs (8 of [50%] 16 patients) in contrast to those not explored previously (5 [15%] of 33 patients). The arterial injury may have been the result of the primary bile duct injury or may be the result of the attempted biliary repair. Several researchers have correlated improved outcomes with the referral of both complex pancreatic and hepatic surgery to tertiary specialty centers for definitive surgical intervention. These data may support the early identification and referral of bile duct injuries to centers specializing in complex biliary surgery. Our study also provided insight into the long-term results of biliary-enteric bypass after vasculobiliary injuries. The overall incidence of recurrent stricture in this series was 18%, with median time to recurrence of 12 months. Although the incidence of recurrent strictures was similar in the CI and NC groups, the mean interval from repair to recurrent stricture was significantly shorter in the CI group with concomitant arterial injuries.

**CONCLUSIONS**

Iatrogenic bile duct injuries have increased since the inception of laparoscopic cholecystectomy, but few researchers have described the significance of associated vascular injuries. Combined arterial and biliary injuries may present with variable clinical scenarios, from minor morbidity to multisystem organ failure. The incidence of arterial injury seems to be associated with higher Bismuth level injuries. The use of hepatic artery angiography should be selective with higher Bismuth level injury and significant hepatic necrosis. Patients with early recurrent strictures should be examined for unrecognized arterial injuries. Based on the residual vascular supply to the liver, surgical interventions can be formulated, varying from simple stenting to formal hepatic lobectomy and, in extreme cases, orthotopic liver transplantation. Early identification and referral to a tertiary center specializing in complex biliary surgery may minimize morbidity and improve the overall outcome of bile duct injuries.

This paper was presented at the 109th Scientific Session of the Western Surgical Association, San Antonio, Tex, November 14, 2001.

**REFERENCES**


**DISCUSSION**

Jack Pickelman, MD, Maywood, Ill: This is a very sobering article and I hope everyone has paid attention to it and will read the manuscript. After reading dozens of articles on bile duct injuries over the years in which superb results are the norm, we finally find someone actually telling the truth. Namely, that laparoscopic ductal injuries are a devastating complication, and long-term disability and death are not infrequent outcomes. Why is this important? The incidence of these laparoscopic injuries has stabilized at around 0.4% to 0.6%. There are numerous state and regional databases to confirm this. There is no learning curve. However, referrals to biliary centers, including ours, are declining. Therefore, we must conclude that these repairs are being performed in the hospitals which produced them. Community surgeons have been conned by the literature into thinking that biliary reconstructions are relatively straightforward and the results predictable. Because of this, they attempt these repairs even though they do so very infrequently. Numerous series, including the present one, attest to the subpar results they achieve. This is the first take-
home message today. Transfer these patients early to an experienced biliary surgeon.

The second important message of the paper deals with the severity of these injuries, stressing their proximal nature and the common accompanying arterial injuries, which can lead to hepatic necrosis or ductal ischemia. The authors stress the importance of performing an angiogram in patients about to undergo a biliary reconstruction. They state that this injury may predict outcome, and I agree. However, I do not see how this alters the conduct of the operation. So why do an arteriogram? Is it prognostic, but it does not change anything at the operation. Perhaps the authors could explain their reasoning here.

My next question has to do with the Bismuth type V injury or transection of the right posterior sectoral duct. Why is this considered a complex injury? Many of us merely ligate this sectoral duct, accept the lobar atrophy, and these patients generally remain very well. There are a number of articles in the literature that would attest to this type of treatment. This seems to be far preferable to attempting repair of a tiny duct in an inflammatory bed.

Lastly, in the patients with injuries involving the hepatic duct confluence, I have personally now performed a portoenterostomy, or Kasai procedure, in 5 such patients, all of whom are symptom free and with normal liver function tests up to 8 years after this operation. This procedure is preferable to very high individual ductal anastomoses or a liver transplant.

In closing, I would recommend that this article, when published, be nailed to the bulletin board in every surgeon’s locker room in this country.

Hung Sy Ho, MD, Sacramento, Calif: I have 2 specific questions. The first one regards the math. According to what I heard, you have 13 patients out of 49 patients who had hepatic arterial injury, so that means about 27%, not 48%.

Then when you look at the critical life-threatening injury group, it is not quite correct that the incidence of arterial injury is 48%; it should be 10 out of 24, which is about 41%. My question is would you recommend angiogram on those specific patients; those with Bismuth type III or higher injury rather than everyone with biliary injury?

Secondly, I am surprised to find out that none of the patients with the critical injury had any percutaneous transhepatic cholangiograms at all. On the occasional bile injury cases that we have been asked to deal with, we found that PTC is actually very helpful in delineating the anatomy preoperatively and allowing us to palpate and locate the site intraoperatively. Can you provide any information as to why these patients had no preoperative PTC? Do you think this lack of PTC may account for the poor outcome that you observed?

William C. Chapman, MD, Nashville, Tenn: I have a couple of questions. I echo the comments of Dr Pickleman that it is really a very alarming report, and your 20% mortality rate in patients that you grouped as complex injuries is significantly dramatically higher than previous reports on this topic. Along those lines, I wonder if you could comment on the status of patients who underwent repair and attempted repair. Did this group of patients have ongoing sepsis, pulmonary failure, renal failure, and other evidence of multisystem failure at the time of their attempted repair? Obviously, these are difficult patients to manage, but, in retrospect, should those patients have not undergone attempted repairs at that point of time? In other words, would it have been preferable to perform drainage and/or debridement of their liver, if required, and only perform definitive repair attempts at a later time when they were more stable?

My second question is whether you think this report represents a more extreme injured group than has been previously reported or have you just recognized a problem that has been present all along? If you look at previous reports, there are subsets demonstrating arterial injuries present in patients with both open and laparoscopic injury, generally in the 10% to 20% range. So, I wonder if this is a different, more extreme injury group, or is this just recognition of a problem that has occurred in both open and lap chole injury cases?

Lawrence Danto, MD, Stockton, Calif: I share the authors’ concern and the discussants’ concern about the lack of referral of these patients. I am not quite sure how to express this, but I wonder about the breakdown in communication between the referral centers and the potential referring physicians, particularly with regard to this very crucial topic of patient care. It occurs in other points of patient care as well, but this is one that is traditionally significant. Have you looked into the reasons for lack of referral? There are obvious socioeconomic reasons. In California, the birthplace of profit-based managed care, there are obvious economic incentives for not referring patients like this. I wonder if you have looked into this at all.

Donald L. Kaminski, MD, St. Louis, Mo: We published a similar series of patients 3 years ago in the Archives of Surgery. I want to make a comment and ask a question. The patients with combined arterial and bile duct injuries raised the concern that these ischemic bile duct reconstructions would fail short and long term. I have followed 5 patients with combined injuries for about 5 years, and these patients have maintained normal liver function and have not developed late strictures. I was very surprised at this. I thought these bile duct reconstructions would all fail. Patients with right hepatic artery occlusion are able to maintain a relatively normal biliary system in the right lobe of the liver even though the arterial supply has been eliminated.

The question I have relates to the arterial injury. Should the arterial injury be reconstructed? There is an old autopsy study that looked at a large number of patients who underwent cholecystectomy. The incidence of ligated right hepatic arteries in that group was something around 10%. The arteries had been ligated during open cholecystectomies, and the patients never suffered any adverse sequelae. As transplant surgeons have shown, you can reconstruct occluded hepatic arteries in a delayed fashion and obtain patency of the hepatic artery. If you are operating on a patient with a combined injury, you can clearly identify the arterial injury at the time of reconstruction. Should you make some attempt at 24 hours or 48 hours to reconstruct the hepatic artery? Does it make any difference long term with regards to the stability of that bile duct reconstruction?

Mellick T. Sykes, MD, San Antonio, Tex: As a vascular surgeon, I just wanted to clarify the process of recognition of the arterial injuries. Did everyone that came in have an arteriogram? Is that how they were recognized, or were arteriograms only done on patients who had hepatic necrosis? Were any of the arterial injuries repaired?

When I did my vascular training at Vanderbilt, Dick Dean noted that with renal artery occlusions, they were rarely an emergency: you either were too late or you had plenty of time. What is the warm ischemic time of the liver in this setting? Do you have any data on that? Lastly, is reconstruction ever entertained?

Thomas Biehl, MD, Seattle, Wash: One of your recommendations was that these patients be referred to a biliary center early. Can you give some specific examples of how the biliary center would have managed these cases differently, or was the injury in itself so severe that very little could be done?

Arthur J. Donovan, MD, Pasadena, Calif: On the matter of occlusion of the hepatic artery, we occlude the hepatic artery rather commonly in the management of trauma or by embolization for tumor management. Do you have any information as to whether possibly there was an additional injury to the portal vein in any of these patients who had adverse effects from the occlusion of the hepatic artery?

Claude H. Organ, MD, Oakland, Calif: I have 3 questions. (1) If I listened to Dr Pickleman carefully, the incidence
of bile duct injuries is not increasing. Is he suggesting and are you suggesting that this is a matter of creative accounting or are these actually occurring? (2) Are you suggesting further that the Bismuth classification should be reclassified and arterial injuries be a part of each of the types he has described? (3) Finally, the report by Northover and Terblanche on the arterial supply to the biliary tract is a very important contribution.

J. David Richardson, MD, Louisville, Ky: I don’t want to appear reactionary, but I believe the message should focus on the avoidance of injury rather than referral to a liver center after the injury has occurred. We are not training surgeons properly to do open operations. Residents and young surgeons have developed a mindset that it is not proper to ever open a patient. Therefore, they keep placing clips when they get into bleeding trouble. Of the radiographs you showed, all had many clips that illustrate how lost some of the surgeons must have been. At some point, we need to be advocates for patient safety and the necessity to convert some of these procedures to open ones.

My question was whether any of these patients with arterial injuries presented with hemorrhage, or were the vascular injuries discovered later?

Dr Organ: Dr Richardson, before you sit, could I ask you one question? If I could assure you that you would have no scar, would you prefer an open or a laparoscopic cholecystectomy?

Dr Richardson: Well, I have thought about this a lot because I figure I am going to get gallstones some day just because I have some of the risk factors. I would want a laparoscopic operation if I really could pick my surgeon carefully. But on the other hand, the last thing I would tell him or her as I went in would be “Now look, if you get into trouble, open me up.”

Dr Buell: Unfortunately, we live in a legal medical environment, and that is the primary reason for angiography at this date. We have referrals of patients who have had 1, 2, 3, even 4 operations prior to their arrival. You don’t know who was responsible for what injury and, as the definitive surgeon, you end up becoming responsible for such. The UCLA group does routine angiography in all patients. At the University of Chicago, during the Broelsch era, selective angiography was used. After Dr Broelsch returned to Germany, we have adopted routine angiography at the University of Chicago, and I currently use this practice at the University of Cincinnati.

The next question was why are we concerned over right posterior ductal injuries. We have seen several patients over the years with long-term follow-up with significant segmental cholestasis and chronic infection in right posterior sectors. In these individuals, certainly I can’t give you an exact incidence, but they will often develop a chronic infection. If it is an easily repairable injury, and as a transplant surgeon, we are becoming more accustomed to performing these biliary anastomosis with living-related liver transplants, we would go ahead and repair these right posterior ductal injuries.

Dr Pickelman, you also brought up the use of a Kasai procedure. This is actually a wonderful procedure. Obviously, in some of the more severe injuries with high confluence injuries, emphysematous or necrotic liver made this procedure impossible. In that situation, for us, a Kasai was not a viable option for these individuals. For those individuals that are caught early before there was any necrosis and an excellent plate to sew to, this is a wonderful idea and should be applauded.

Dr Ho, the slide that we presented identified the initial test identifying the injury. All of our patients have a PTC placed, either a single-sided or most commonly, bilateral, and all anastomoses were performed over catheters. That way we have access and can follow them postoperatively.

Dr Chapman, it is a concern. Do we take these patients to the operating room and induce injury? The majority of these patients were operated on multiple times, had multiple drains in place, and still had necrotic liver, some instability, and we were often forced to proceed with some surgical endeavor or type of resection at that interval. There are several other patients that succumbed to their disease, developing ARDS or some other type of sepsis postoperatively. If you can drain an individual and cool them down for several weeks or several months, this should be done. In the situation where multiple surgeons had attempts at them and they were adequately drained but still septic or had necrotic liver, we were forced into the situation.

Dr Dunno, obviously referral systems are very important. In a competitive city, like Chicago, people belong to different medical systems, and several of our patients were referred through their medical system from one institution to another institution. After the “definitive operation” at the higher institution in another system, they were then referred over to the university. Obviously, in the University of Cincinnati, it is a much better situation where we actually bring patients in from the tri-state area, and our center repairs the majority of bile duct injury, so it is done in a more controlled situation.

Dr Kaminski, as a transplant surgeon, hepatic artery thrombosis is the bane of our existence, especially if a replaced right artery thromboses, you have resulting necrosis of your biliary tree, and then you are stuck with a situation where you need to retransplant a liver in most cases. When is too late too late? Usually, that interval is about 8 to 12 hours. If you can identify a patient intraoperatively or within a reasonable interval, less than 12 hours, returning back to the operating room and doing a primary repair, either with end-to-end anastomosis or saphenous vein graft, is a very reasonable method of management of these patients. Even with repair we should always worry about biliary necrosis or sloughing, which we can see quite often in patients with hepatic artery thrombosis after liver transplantation.

Dr Organ, we have to consider Dr Bismuth’s classification as very important and very helpful for individuals, but it does not address arterial injuries. That is a real deficiency in the system, and we should consider whether or not an addition or notation that those patients with arterial injuries be placed in a different classification with their own defined morbidity and mortality.

Dr Donovan, you asked about portal vein occlusion. The case of chemoembolization addresses this issue with these procedures, usually single sided and sometimes bilaterally; there is a known incidence of necrosis when you perform a bilateral occlusion. No patient in our study had a portal vein injury and from our colleagues at the University, who perform multiple chemoembolizations. The incidence of hepatic necrosis in these cases is about 3% to 15%, depending on the series of individuals just having a chemoembolization. This phenomenon does exist, and it is a serious complication. Obviously, we would be more concerned if we had a portal vein injury concomitant with an arterial injury.

Lastly, Dr Richardson, several of our patients were noted in their operative reports to have significant hemorrhage, and, subsequently, lots of clips were blindly placed to control hemorrhage and then we were referred. In the era of laparoscopic–every type of surgery, we need to be very judicious about our surgical training and our procedures.

Intraoperative fluoroscopy, especially live time, is probably pretty essential to training residents because there are a small number of open cholecystectomies done by residents during their training to be comfortable with the hepatobiliary system, and intraoperative fluoroscopy allows these residents to identify and learn the aberrancies of the biliary ductal system. As they feel comfortable, when a conversion is needed they can identify when they are too close to the CBD, leaving a cystic duct short or pulling up, tenting, and dividing a common duct, that they can also decide when they need to convert and do an open procedure in their own practice.