Hypothesis: The Hepp-Couinaud approach to biliary enteric reconstruction for laparoscopic bile duct injuries provides a durable, long-term result in most patients.

Design: Retrospective study of patients who underwent operative repair of laparoscopic bile duct injuries from January 1990 through December 1997.

Setting: Academic tertiary referral center.

Main Outcome Measures: Outcome was assessed using a grading system based on clinical symptoms, liver function tests, and need for reintervention for anastomotic stricture. The Kaplan-Meier method was employed to estimate stricture-free survival.

Results: Fifty-nine consecutive patients underwent operative repair of the following laparoscopic bile duct injuries (Strasberg classification): B: n = 2 (3%), C: n = 1 (1%), D: n = 2 (3%), E1: n = 5 (8%), E2: n = 16 (27%), E3: n = 25 (42%), E4: n = 5 (8%), and E5: n = 3 (5%). Forty-seven patients (80%) had 1 or more interventions prior to the index repair. The extrahepatic left bile duct (Hepp-Couinaud approach) was used in 46 of 53 patients who underwent a Roux-en-Y hepaticojejunostomy. Follow-up (mean ± SEM, 3.7 ± 0.3 years) was complete in 54 of the 57 patients still alive. Five patients developed subsequent anastomotic strictures and were treated with percutaneous transhepatic dilation (n = 3), endoscopic dilation (n = 1), and operative revision (n = 1). Excellent to good long-term results were achieved in the remaining 49 patients (91%). Life-table analysis yielded 95% and 88% chances of stricture-free survival at 2 and 5 years, respectively.

Conclusions: Complex iatrogenic proximal bile duct injuries and strictures are amenable to operative repair using the extrahepatic left bile duct. The Hepp-Couinaud approach offers a durable result in more than 90% of patients, even after previous interventions have failed.

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Iatrogenic injuries to the bile ducts are uncommon entities in clinical practice that have been encountered more frequently after the advent of laparoscopic surgery. The pattern of bile duct injuries occurring during laparoscopic cholecystectomy seems to differ from those injuries sustained during an open procedure; many occur in a more proximal location and the resultant strictures are more extensive. The fact that as many as 15% of such operative repairs for bile duct injuries had to be revised underscores the complexity of these injuries and the need for long-term follow-up.

The long-term success of repairing iatrogenic laparoscopic bile duct injuries is difficult to assess because many of the reports in the literature contain a small number of patients or have a short follow-up period. A previous report from our institution outlined the pattern of the initial wave of complications from laparoscopic cholecystectomy and their treatment. That experience was reported expeditiously to alert surgeons to the increasing incidence of serious bile duct injury, and hence a long follow-up period was not practical.

The aim of this study was to report the long-term results of biliary reconstruction for laparoscopic duct injuries using the Hepp-Couinaud approach, which incorporates the extrahepatic portion of the left main hepatic duct (Figure 1).

**RESULTS**

**PATIENT CHARACTERISTICS**

Fifty-nine patients (8 men and 51 women aged 45±2 years) underwent repair of iatrogenic laparoscopic bile duct injuries at the Mayo Clinic (January 1990–December 1997). All patients were referred from other institutions at variable periods after sus-
MATERIALS AND METHODS

The medical records of all 59 consecutive patients (January 1990 through December 1997) who underwent operative repair of laparoscopic bile duct injuries at the Mayo Clinic, Rochester, Minn, were reviewed. The records were abstracted for demographic information; preoperative and postoperative clinical characteristics, including symptoms, laboratory values, and imaging studies; and subjective assessment of the quality of life. Due to the nature of our tertiary practice, it was not practical for some patients who reside in different states and countries to have long-term follow-up at our center. Hence, postoperative follow-up was arranged with local physicians who communicated results of laboratory and imaging studies to us. In this subset of patients, critical aspects of postoperative care, such as removal of transanastomotic biliary stents, were determined by our surgeons after review of pertinent contrast studies obtained at local facilities. A detailed questionnaire was mailed to all patients by a dedicated survey research center at our institution. Nonresponders were subsequently contacted by telephone. Follow-up information was pooled from postoperative visits at our center, contacts from referring physicians, and the results of the follow-up survey.

STRUCTURE CLASSIFICATION

All pertinent imaging studies were reviewed by 2 of us (M.M.M. and M.B.F.), and strictures were classified according to Strasberg et al9 (Figure 2). The classification of strictures was primarily based on ductal anatomy as it appeared on percutaneous transhepatic cholangiography. When percutaneous transhepatic cholangiography was not done or not available for review, strictures were classified based on other imaging studies, such as endoscopic retrograde cholangiopancreatography, and the impression of our attending surgeon at the time of the index repair as documented in our operative records. In 5 patients whose original contrast studies were not available for review, the injuries were classified based on reports in the medical record and operative description at the time of index repair.

OUTCOME MEASUREMENTS

Outcomes of operative repair of bile duct injury were graded according to a classification that accounts for both subjective criteria (symptoms of pain, jaundice, and cholangitis) and objective criteria (serum liver function tests, need for reintervention).10 Patients were graded as excellent (asymptomatic and normal serum liver function test results), good (asymptomatic, mildly abnormal liver function test results), or poor (symptomatic and abnormal liver function test results). Patients who required postoperative intervention for management of recurrent strictures were considered to have treatment failure(s).

DATA ANALYSIS

Life-table analysis using the Kaplan-Meier method was employed to estimate the stricture-free survival in patients who underwent reconstruction using the Hepp-Couinaud approach. The 95% confidence intervals were plotted on all survival curves. For the purposes of calculating the duration of follow-up, intervention for a postoperative stricture was considered an end point. Data are reported as mean ± SEM, unless otherwise indicated.
hepaticojejunostomy in 7 patients who had E1 (n = 2), E2 (n = 4), and E3 (n = 1) strictures. The remaining 6 patients had a Roux-en-Y cholangiojejunostomy (n = 3), choledochorraphy (n = 2), and hepaticoduodenostomy (n = 1). Transanastomotic stents were used in 43 patients for 45±3 days postoperatively. The length of stay was 9±0.5 days.

COMPLICATIONS

One patient died 13 days postoperatively from pancreatitis and renal insufficiency that progressed to multisystem organ failure. She had 2 prior interventions and was in respiratory failure when transferred to our center.

Fifty-two patients (88%) had no postoperative complications. Ten complications developed in 7 patients: intra-abdominal abscesses (n = 3), wound infection (n = 3), cholangitis (n = 2), hemobilia (n = 1), and pancreatitis (n = 1). One of the abscesses was the result of an anastomotic leak; all abscesses were treated successfully with percutaneous drainage. At the time of last follow-up, none of these patients had developed any postoperative strictures. In all patients with wound infection, the condition responded to wound drainage and antibiotic treatment.

FOLLOW-UP

At the time of the study, 2 patients had died. One patient, mentioned above, died of multisystem organ failure, and another died at home of myocardial ischemia 42 days postoperatively. Fifty-seven patients were available for follow-up, 50 of whom responded to the survey in 1998. Four patients did not respond in 1998 but had responded to our earlier survey in 1995. Three patients (5%) were lost to follow-up (no current or forwarding address or international patients). Mean follow-up was 3.7 ± 0.3 years. The longest follow-up period was 7.3 years.

OUTCOMES

Final outcome was graded in 54 patients (2 died and 3 were lost to follow-up). Forty-six patients (85%) had excellent results, 3 patients (6%) had good results, and 5 patients (9%) subsequently developed anastomotic strictures that required intervention. These patients were con-
considered to have treatment failure (Table 3). Four patients were treated at our center with percutaneous transhepatic (n = 3) or endoscopic (n = 1) dilation. The fifth patient had operative revision of the biliary-enteric anastomosis at another facility 4.5 years after the index operation at our center. Life-table analysis predicts 95% and 88% chances of stricture-free survival, respectively, at 2 and 5 years when the Hepp-Couinaud approach is used (Figure 3).

**COMMENT**

The incidence of laparoscopic bile duct injuries has recently been observed to plateau. It is estimated that major bile duct injury occurs in approximately 0.5% to 0.6% of patients undergoing laparoscopic cholecystectomy as opposed to 0.2% to 0.4% during open cholecystectomy.

Injuries to bile ducts can be avoided by meticulous attention to the anatomical variants in the hepatocystic triangle and adherence to principles of safe dissection in that area. Information about the conduct of laparoscopic cholecystectomy was available for our review in only 24 patients, making it difficult to classify the mechanisms of injury (eg, avulsion, transection, or electrocautery) with an acceptable and reliable degree of certainty. Invariably, when the injury was recognized intraoperatively, the surgeon’s note indicated the presence of “biliary anomaly.” In other cases, when an intraoperative cholangiogram was obtained, the imaging study was interpreted as normal by the operating surgeon at the time of cholecystectomy.

We have adopted a modification of the Bismuth classification of bile duct strictures advocated by Strasberg et al to account for injuries that occur during laparoscopic cholecystectomy with or without the subsequent development of strictures (Figure 1). We have found that the modified classification allows uniform reporting and communication among hepatobiliary surgeons. This classification allows reporting of injuries that can be treated by nonoperative means, such as endoscopic stenting in the case of lateral injuries (class D) or cystic duct or duct of Luschka leaks (class A).

Prior to referral to our institution, an attempt to correct the injury after it was recognized was undertaken in 80% of patients, with one or a combination of operative, endoscopic, or percutaneous procedures. Immediate surgery may fail because of both the small size and thin wall of the ducts. In addition, concomitant bile leak, perianastomotic infection, and inflammation are unfavorable conditions for immediate repair. We believe that the final extent of injury and strictures evolves over time as the ischemic ductal tissue is replaced with fibrotic scar tissue. This may result in underestimation of the extent of the stricture and may explain why so many immediate repairs have a propensity to fail.

Precise diagnosis is crucial and all intrahepatic ducts must be visualized; hence, percutaneous tranhepatic
cholangiography is our modality of choice to delineate biliary anatomy and the proximal extent of the stricture. Other useful modalities, such as endoscopic retrograde cholangiopancreatography, may not visualize the proximal extent of the stricture in the case of complete or near complete obstruction, or in injuries that involve accessory or sectoral ducts that do not communicate with the rest of the intrahepatic bile ducts. Although preoperative decompression of the bile ducts is a matter of debate in obstruction secondary to malignant neoplasms, we regard it as a useful adjunct in intraoperative localization of bile ducts and postoperative stenting of the anastomosis. Our practice is to limit the duration of postoperative stenting differs from that of others, who have used stents up to 14 months as an integral part of biliary-enteric anastomoses. We used stents both to decompress the biliary tree in the immediate postoperative period and to obtain postoperative contrast studies. The contrast studies are obtained to assess the integrity of the anastomosis and confirm drainage of all components of the intrahepatic biliary tree.

The optimal timing of repair following injury has not been clearly established. We have based our approach on clinical characteristics. In patients presenting with complete occlusion and no bile leak, the definitive repair can be undertaken when the bile ducts become dilated. Percutaneous tubes can be intermittently clamped to allow dilation up to a diameter of 10 mm. Operation can be undertaken within 2 to 3 weeks of injury in this instance. In patients with evidence of bile leak, biliary fistula, or bile peritonitis, we delay repair to allow the inflammation to subside and also to allow the ducts to dilate, typically 3 to 6 months later.

We believe that the proper use of operative techniques may be the most important predictor of success in biliary reconstruction. We initially became familiar with the Hepp-Couinaud technique in 1982, were encouraged by our initial experience with the technique for benign strictures, and have used it exclusively for proximal strictures since then. In that report, 45 patients had iatrogenic strictures, most of which (n = 26) followed open cholecystectomy. The Hepp-Couinaud technique was used in 21 patients and was compared with standard techniques for the remaining 24 patients. With a median follow-up of 4.6 years, 95% (n = 20) of the patients treated with the Hepp-Couinaud technique achieved excellent or good results. At the time of last follow-up, none of those patients had required reintervention.

The Hepp-Couinaud technique capitalizes on the extrahepatic course of the left main hepatic duct. Incising the investing fascia that condenses around the porta hepatis and forms the “hilar plate” allows easy exposure of the extrahepatic left hepatic duct. The left hepatic duct is an excellent choice for repair of proximal stricture because its location at the base of segment IV and its investing fascia protect it from iatrogenic injury and the inflammatory reaction engendered by bile leakage and infection. In addition, it has a rich blood supply that is not affected by the iatrogenic event, in contrast to the tenuous axial blood supply of the common hepatic and bile ducts.

While most patients who had hepaticojejunostomy in the present study, 46 (87%) of 53 patients, underwent repair using the Hepp-Couinaud technique, for patients with more distal injuries (class E1 and selected class E2), the presence of pliable, well-vascularized duct below the confluen may allow repair without the necessity for elevation of the hilar plate and incision along the left main duct. Six patients, 2 with class E1 and 4 with class E2 injuries, were treated in this manner, and all were graded as excellent at follow-up.

Excellent to good results in most patients (>85%) have been achieved by others using Roux-en-Y hepaticojejunostomy. However, these reports do not stratify results by whether the Hepp-Couinaud approach was used, and they include patients with injuries secondary to heterogeneous causes, such as cholecystectomy, pancreatitis, trauma, or choledochal cysts. In sharp contrast, in 1 recent report in which the authors did not use the Hepp-Couinaud technique, all 4 patients with E1 and E2 (Bismuth class III and IV) strictures were symptomatic at follow-up. In addition, the authors’ claim that longer follow-up will improve their results is unfounded because the narrowed diameter of such anastomoses will not increase over time.

Excellent or good results were obtained in 33 of 38 and 48 of 52 patients treated for laparoscopic bile duct injuries in 2 centers with substantial expertise in biliary surgery. The authors do not indicate when the Hepp-Couinaud approach was used. However, judging from the distribution of injuries, it is likely that the Hepp-Couinaud approach was used to repair the more proximal strictures. The results in the present study for repair using the Hepp-Couinaud approach parallel our previously reported results with benign strictures and compare favorably with other reported series.

Four of 5 patients in the present study in whom the index repair failed share common characteristics.

<table>
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<th>Injury Classification†</th>
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</table>

* TH indicates percutaneous transhepatic dilation; RHA, injury to right hepatic artery. The index repair was Roux-en-Y hepaticojejunostomy and the Hepp-Couinaud approach. There was no postoperative morbidity.
†According to Strasberg et al.
Iatrogenic bile duct injuries and strictures are a complex challenge to the treating physician. Operative treatment of complex proximal strictures achieved excellent to good long-term results in more than 90% of patients. The Hepp-Couinaud approach of using the extrahepatic left bile duct offers durable results even in patients for whom previous repairs failed. These operations are best undertaken by surgeons experienced in biliary surgery after the sequelae of bile leakage have subsided. Treatment outcomes should take into account the expertise and interest in biliary surgery.

The financial ramifications of iatrogenic bile duct injuries are well documented. All our patients except 2 have alleged negligence and sought compensation for their bile duct injury.

CONCLUSION

Iatrogenic bile duct injuries and strictures are a complex challenge to the treating physician. Operative treatment of complex proximal strictures achieved excellent to good long-term results in more than 90% of patients. The Hepp-Couinaud approach of using the extrahepatic left bile duct offers durable results even in patients for whom previous repairs failed. These operations are best undertaken by surgeons experienced in biliary surgery after the sequelae of bile leakage have subsided. Treatment outcomes should take quality of life issues into consideration.


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REFERENCES


Robert Rege, MD, Dallas, Tex: Currently, the rate of bile duct injury with laparoscopic cholecystectomy is reported to be about 0.2%, or 1 in 500. The incidence is high enough to make it of concern to surgeons in the surgical community, but not high enough that any given surgeon will develop a large series of patients. Though this patient series is quite extensive, the outcome in these patients was deemed to be good and excellent in 90% of the patients despite the fact that 80% of the patients had previous intervention before their index repair. The results in these series compare very favorably with the best results reported in the literature. The authors attribute their success to the Hepp-Couinaud approach, in which a 2- to 3-cm anastomosis is constructed between a Roux-en-Y jejunal loop and the extrahepatic left bile duct. This approach was used in 46 of 53 patients requiring a hepaticojunostomy reconstruction. During a mean follow-up period of 3.7 years, 5 of these patients developed a late postoperative stricture. Four of the patients required therapy that was nonoperative, and 1 had operative therapy at another institution. These strictures are considered their failures. Therefore, the failure rate for the Hepp-Couinaud approach was about 10% to 11%. It is important to understand that the patients who developed strictures developed them between 1 and 5 years after the reconstruction, showing that these patients are always at risk for developing late postoperative strictures.

I would like to ask several questions. Seven of the patients underwent a Roux-en-Y hepaticojunostomy without the Hepp-Couinaud technique and none developed late stricture. Why and when was an approach used other than the Hepp-Couinaud approach? Is the Hepp-Couinaud approach what the authors would use in patients who had primary duct repairs, as opposed to the ones referred later, after they have had a failed procedure? The patients were rated as excellent if they were asymptomatic and had normal liver function tests. Three patients were rated as good, and they had abnormal liver function tests but were asymptomatic. How many of the failures de-
veloped abnormal liver function tests and were asymptomatic before the stricture was found? To ask this question another way, are the 6% of patients in the good category likely to develop strictures in the future?

The study deals largely with repairs at a tertiary center in patients who had previous procedures that failed. Based on their experience, could the authors recommend their approach for the surgeon who recognizes an injury at the time of surgery, or shortly thereafter? I would also like the authors to expound on the need for postoperative stenting and the duration of stenting when it was used. In their study, they used stenting in most of their patients, but it was discontinued earlier than in some of the other series in the literature. My question is, is stenting necessary, and how long would that stenting be recommended? What was the course of the patients after the percutaneous dilation for their late stricture? In those 4 patients, did they require repeat dilations? Are they symptomatic now and do they have abnormal liver function tests?

Frank Moody, MD, Houston, Tex: I also want to congratulate the authors on their success but ask the question about the 3 people who seem to have disappeared from the face of the earth. Have you found them since you put together the paper? Shouldn’t they be included as maybe questionable in terms of their outcome?

You might expand a little bit on how you did the anastomosis. Is it as Blumgart tells us, with a single layer and sort of parachute it down?

Maybe you could tell us whether the 5 people who have obviously failed had a little bit more difficult time in getting the intestine to the bile duct.

Finally, tell us about the deaths; while it was not 30 days for 1 death to occur, it was 42 days, and from a myocardial infarction. Was this one of these early discharges to Houston possibly, or some other place, in which the patient really was having some problems in the hospital at the time of discharge, but the significance was unrecognized?

Lawrence Koep, MD, Phoenix, Ariz: Do you have any concomitant hepatic artery injuries? If so, did you see that as correlating with the failure rate?

Dr Farnell: There was a question concerning why the Hepp technique was not used in 7 patients. There were 2 reasons: first, many of those patients had injuries that were very distal in the bile duct and thus it was not necessary to get up to the confluence to do the repair, and secondly, by surgeon preference. I must point out that there were a number of surgeons performing these repairs and not all of the surgeons perhaps embraced the Hepp technique.

Dr Rege asked what advice we would give a surgeon who recognizes an injury at the time of surgery. This is a difficult question to answer and it depends greatly on the expertise of the surgeon involved. We often will receive a call while the surgeon is in the operating room telling us that they have attempted a laparoscopic cholecystectomy, have opened, and they see bile issuing forth from the confluence from more than 1 duct. Our advice in that situation generally is to drain, close, and refer the patient. What we will do when we receive the patient is to gain control of the biliary tree, drain any collections, and defer operation. We have been pleased with the technical aspects of the Hepp-Couinaud technique in terms of the results that are reflected here, but the timing of the operation is particularly critical. For those patients who have occlusion without contamination or peritonitis, early reconstruction within a few days or a week or so is technically feasible. For those patients who have injury associated with leakage, it is our preference to gain control, allow them to convalesce and allow the inflammatory process to settle down, and then do an elective reconstruction. Operation is delayed approximately 3 months to allow for optimal local conditions for reconstruction.

What about stenting? It has been our practice to stent the majority of these patients. Our preference is to place stents preoperatively. These are typically pigtail-type catheters. When we perform the reconstruction, we leave the transhepatic and trans-anastomotic stent in place, primarily for 2 reasons. One is to decompress the anastomosis in the immediate perioperative period and secondly to perform cholangiography prior to removal of the stent. We feel that the decompression is helpful and cholangiography is useful in confirming the integrity of the anastomosis. It allows us to prognosticate, if you will, with regard to the quality of the anastomosis and allows us to perhaps anticipate problems. Our usual practice is to remove the stents approximately 21 days postoperatively. In the manuscript the average was about 45 days, so obviously there are some patients who for extenuating circumstances have the tubes in for longer periods of time.

There was a question about the failures and Dr Koep asked about hepatic artery injury. To our knowledge, there was only 1 patient in the series who had a right hepatic artery injury, and that patient did fail. The slide illustrates the therapies that were used in these 5 patients (Table 4). There were 3 patients who had transhepatic dilatations. There was 1 patient who had the native bile duct still in continuity, and there was a partial occlusion distal to the anastomosis, and endoscopic dilatation was possible in that patient. Lastly, there was 1 patient who had surgery at another institution. At the time of follow-up all of these patients were salvaged and were doing well.

Dr Moody asked about the technical aspects of the anastomosis, and indeed, we do perform it very much as Blumgart has described. We use a single layer of absorbable suture, typically a 4.0 or 5.0, and perform the anastomosis end-to-side. We are extremely careful to try to obtain supple, pliable bile duct proximal to the level of inflammation. The Achilles heel of this operation is the orifice of the right duct. In patients we have operated on with type E3 and type E4 injuries, those at or near the confluence, one can usually obtain excellent left main duct to work with. If the stricture extends to the orifice of the right duct, this is the area that is difficult to get a technically satisfactory anastomosis. Indeed, in those patients who failed, the site of failure was at the orifice of the right main duct. Accordingly, the dilatation required was not of the left main duct, but of the orifice of the right anterior or posterior duct.

Dr Moody also asked about the patients who died. I should comment that 1 patient died in the early postoperative period, and that patient was operated on not only because the patient had a bile duct injury, but primarily because an endoscopic sphincterotomy, which had been performed prior to referral, resulted in retroperitoneal necrosis. The operation was done because of sepsis. The patient who died 42 days postoperatively after discharge from the hospital had been seen in consultation preoperatively by our cardiac surgeons on 2 occasions in an effort to consider revascularization prior to planned biliary surgery. It was determined by the cardiac surgeon that operation was not indicated. Unfortunately, in spite of an uneventful postoperative course, after dismissal the patient developed an inferior myocardial infarction and bradycardia and died.

Dr Moody also asked and commented about the patients lost to follow-up. Unfortunately, some of those patients are international and we have not to date been able to find them. Even if one were to ascribe the patients lost to follow-up to a poor outcome, we still feel that on the whole, this technique and this approach give us good results.