Clinical Science

The difficult hepaticojejunostomy after pancreatic head resection: reconstruction with a T tube

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KEYWORDS: Hepaticojejunostomy; Bile leak; Pancreatic surgery; T tube

Abstract

BACKGROUND: After pancreatic head resection, bile leaks from a difficult hepaticojejunostomy secondary to a small or fragile common hepatic duct may be reduced by a T tube at the side of the anastomosis.

METHODS: A retrospective analysis of patients who underwent a difficult hepaticojejunostomy without or with a T tube was performed.

RESULTS: In 48% (55/114) of patients, a T tube was placed at the side of the hepaticojejunostomy; 52% (59/114) did not have a T tube. Bile leaks occurred in 12% (14/114) (9% [5/55] in patients with a T tube vs 15% [9/59] without a T tube, P = .316). Bile leaks were associated with mortality, abscess formation, hemorrhage, and sepsis. Seven percent (8/114) of patients required revisional laparotomy (2% [1/55] with a T tube vs 12% [7/59] without a T tube, P = .036). Mortality was not different between the groups. Minor T-tube–associated complications occurred in 15% (8/55) without major complications.

CONCLUSIONS: Augmentation of anastomosis with a T tube cannot prevent biliary leakage but does reduce the severity of bile leaks, resulting in less reoperations.

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The risk of bile leaks after pancreatic head resection varies between 2% and 12%.1,2 Although a bile leak is a rare surgical complication, it is associated with postoperative morbidity and mortality, even in specialized units.3,4

Most trials analyzing postoperative morbidity and mortality after pancreatic surgery focus on pancreatic leakage, whereas studies analyzing postoperative bile leaks are scarce.

During the last 2 decades, improvements in surgical technique and intensive care management reduced morbidity and mortality from pancreatic fistula after pancreatic head resection.5,6 Furthermore, a uniform definition and severity grading of pancreatic fistula enabled a comparison of different clinical trials, facilitating diagnostic and treatment modalities.7 A comparable definition and scoring system for the severity of postoperative bile leaks was proposed recently but is not available yet.8

Today, physicians should avoid preoperative biliary drainage in patients with obstructive jaundice because bile duct stenting is associated with an increased risk for postoperative infectious complications.9 However, many patients with pancreatic carcinoma still undergo preoperative...
biliary drainage, which leads to bile duct dilation and thickening of the bile duct wall.\textsuperscript{10} In these patients, suturing the hepaticojunostomy is technically easy, whereas it is difficult in patients with a small common hepatic duct diameter or a thin and fragile common hepatic duct wall (eg, in chronic pancreatitis or tumors of the uncinate process or benign periampullary lesions).\textsuperscript{11,12} These patients often have a small common hepatic duct diameter with a thin common hepatic duct wall, resulting in a difficult hepaticojunostomy with an increased risk for postoperative bile leaks.\textsuperscript{13,14}

Although the routine use of T-tube drainage after liver transplantation remains controversial, the placement of transanastomotic biliary drainages is a well-accepted technique for a difficult hepaticojunostomy after bile duct injuries or benign bile duct strictures.\textsuperscript{15–19} Thus, a temporary biliary diversion with a T tube that is brought out through the anastomotic site for patients with a difficult hepaticojunostomy after pancreatic head resection may help to reduce the risk of postoperative bile leaks.

The goal of this study was to describe the frequency of bile leaks from the hepaticojunostomy in patients with a difficult hepaticojunostomy after pancreatic head resection at a specialized pancreatic center and to analyze the safety and efficacy of placement of a T tube at the side of the hepaticojunostomy.

**Methods**

The study was an observational cohort design. All patients who underwent pancreatic surgery at the Department of Surgery, St. Josef Hospital, Ruhr University Bochum, Germany, were entered into a prospectively collected database. Charts and operation protocols of all patients who underwent pancreatic head resection or total pancreatectomy for both benign and malignant periampullary lesions were analyzed for study purposes.

Reconstruction was performed by a standardized end-to-side pancreaticojunostomy using absorbable and nonabsorbable double-layer interrupted sutures without placement of pancreatic duct stents. End-to-side hepaticojunostomy was performed 1 cm distal to the common hepatic duct bifurcation 10 to 20 cm distal from the pancreaticojunostomy using the same jejunal loop with a single-layer suture with polydioxanone 6/0 for each wall of the anastomosis. Hepaticojunostomies were performed by 3 different attending surgeons with experience of more than 30 bilioenteric anastomoses in the study period.

Criteria for the presence of a difficult hepaticojunostomy were a small common hepatic duct diameter (<5 mm) or a fragile common hepatic duct wall, as documented in the operation protocol or on preoperative magnetic resonance cholangiopancreatography imaging. A fragile common hepatic duct was defined as a thin common hepatic duct wall that was sutured with polydioxanone 6/0 sutures to avoid a breakdown of the wall of the common hepatic duct. During the 1st part of the study (January 2004 to September 2007), reconstruction among patients with a difficult hepaticojunostomy was performed without a T tube. During the 2nd part of the study (October 2007 to February 2009), reconstruction included the placement of a T tube that was brought out through the site of the anastomosis. One part of the horizontal limb of the T tube was placed into the common hepatic duct; the other part was placed into the jejunal loop, whereas the vertical part of the drain was brought out through the abdominal wall. T tubes were controlled for leakage between the 5th and the 7th postoperative day by the application of water-soluble contrast medium (Gastrografin; Firma Bayer, Leverkusen, Germany). Patients did not receive antibiotics before T-tube cholangiograms. T tubes were routinely removed 6 to 8 weeks postoperatively.

All patients had 2 flat silicon drainages placed at the side of the hepaticojunostomy and the pancreaticojunostomy. A bile leak was defined as a bilirubin concentration in the drainage fluid 3 times above the serum bilirubin concentration starting at the 1st postoperative day or as the need for radiologic or operative intervention secondary to biliary collections or biliary peritonitis. No transhepatic drainages were used for the management of postoperative bile leaks. The severity of biliary leakage was classified according to the International Study Group of Liver Surgery.\textsuperscript{7} A bile leak without clinical symptoms with a mildly impaired clinical condition resolving without active therapeutic intervention within 1 week was classified as a grade A fistula. The presence of a grade A fistula did not result in a strategy change on postoperative management. A bile leak that required active therapeutic intervention secondary to an impaired clinical condition with signs of infection on imaging or laboratory results was classified as a grade B fistula. Patients with a grade B fistula underwent active therapeutic intervention including interventional drainage and antibiotic therapy but no operative revision. A bile leak that severely impaired patients’ clinical condition, including signs of sepsis, single- or multiple-organ failure, or the presence of biliary peritonitis, was classified as a grade C bile leak. Patients with grade C bile leaks underwent relaparotomy.\textsuperscript{8}

A postoperative pancreatic leak was defined as a drain fluid amylase level 3 times above serum concentration on the 3rd postoperative day according to the International Study Group on Pancreatic Fistula definitions.\textsuperscript{7} Intra-abdominal abscess formation was defined as a localized infection, which required percutaneous drainage or reoperation. Cholangitis was defined as a fever with right upper quadrant pain and elevated liver enzymes or bilirubin in the absence of other infectious complications according to the Tokyo guidelines.\textsuperscript{20} Patients with cholangitis after T-tube removal were also included. Wound infection was defined as a positive culture collection that prolonged hospital stay or required secondary wound suturing or refashioning. Delayed gastric emptying was defined as the inability for oral food intake 14 days after surgery. Mortality was defined as death during hospital stay. The study was approved by the local review board.
Statistical analysis

Unvaried analyses of variables were performed with the chi-square test. The Student t test was used for equality of means. Otherwise, the Wilcoxon-Mann-Whitney test was used when appropriate. A P value less than .05 was considered statistically significant. All statistical analyses were performed with SPSS version 18.0 software (SPSS Inc, Chicago, IL).

Results

Demographic details

Between January 2004 and February 2009, 1,153 patients underwent pancreatic surgery at St. Josef Hospital. Among those, 114 patients had a difficult hepaticojejunostomy. Fifty-two percent (59/114) of patients had a reconstruction without a T tube, whereas 48% (55/114) of patients had a hepaticojejunostomy with a T tube that was brought out through the anastomosis. Demographic details are listed in Table 1. There were no differences for postoperative diagnosis or for postoperative hospital stay between both groups (Table 1).

Operative procedures

Operative procedures included pylorus-preserving duodenopancreatectomy, classic duodenopancreatectomy, and total pancreatectomy. One patient with chronic pancreatitis underwent a modified duodenum-preserving pancreatic head resection with a hepaticojejunostomy. There were no differences between patients with a T tube versus patients without a T tube and the operative procedures performed (Table 2).

Postoperative morbidity and mortality

Overall, 53% (60/114) of patients had at least 1 postoperative complication (55% [30/55] in the group with a T tube vs 51% [30/59] in the group without a T tube [P = .693]). Mortality was 5% (6/114) (4% [2/55] among patients with a T tube vs 7% [4/59] among patients without a T tube [P = .453]). Details of postoperative morbidity and mortality are listed in Table 3.

Postoperative bile leaks

Among all patients with a difficult hepaticojejunostomy, 12% (14/114) had a bile leak (9% [5/55] in the group with a T tube vs 15% [9/59] in the group without a T tube, P = .316). The presence of a bile leak was significantly associated with mortality (29% [4/14] vs 2% [2/100] [P = .001]), intra-abdominal abscess formation (36% [5/14] vs 2% [2/100], P = .001), postoperative hemorrhage (29% [4/14] vs 4% [4/100], P = .001), and sepsis (21% [3/14] vs 2% [2/100], P = .001). There was a trend toward more bile leaks in patients with benign periampullary lesions, but the difference was not significant.

Postoperative management of patients with bile leaks

A grade A bile leak was found in 3% (3/114) of patients (6% [3/55] among patients with a T tube vs 0% [0/59] among patients without a T tube, P = .069). None of these 3 patients required antibiotic therapy or interventional drainage. T tubes were unclamped, and bile leaks closed spontaneously within 1 week among all 3 patients. A grade B bile leak was present in 3% (3/114) of patients (2% [1/55] in the T-tube group vs 3% [2/59] in the group

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Demographic data</th>
</tr>
</thead>
<tbody>
<tr>
<td>All patients</td>
<td>T tube</td>
</tr>
<tr>
<td>Number of patients (%)</td>
<td>(N = 114)</td>
</tr>
<tr>
<td>Mean age (y)</td>
<td>60 ± 14</td>
</tr>
<tr>
<td>Sex (%)</td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>55 (63/114)</td>
</tr>
<tr>
<td>Female</td>
<td>45 (51/114)</td>
</tr>
<tr>
<td>Postoperative hospital stay (d)</td>
<td>19 ± 13</td>
</tr>
<tr>
<td>Malignant tumors (%)</td>
<td>51 (58/114)</td>
</tr>
<tr>
<td>Pancreatic cancer</td>
<td>31 (35/114)</td>
</tr>
<tr>
<td>Distal bile duct cancer</td>
<td>5 (6/114)</td>
</tr>
<tr>
<td>Duodenal cancer</td>
<td>3 (3/114)</td>
</tr>
<tr>
<td>Ampullary cancer</td>
<td>6 (7/114)</td>
</tr>
<tr>
<td>Other malignant tumors*</td>
<td>6 (7/114)</td>
</tr>
<tr>
<td>Benign diseases (%)</td>
<td>49 (56/114)</td>
</tr>
<tr>
<td>Chronic pancreatitis</td>
<td>32 (36/114)</td>
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<tr>
<td>Other benign tumors†</td>
<td>18 (20/114)</td>
</tr>
</tbody>
</table>

*Malignant intraductal papillary mucinous neoplasm and pancreatic head metastases from other tumors (renal cell carcinoma and breast cancer).
†Benign intraductal papillary mucinous neoplasm and cystadenoma.
without a T-tube, \( P = .000 \). All 3 patients required interventional drainage and received antibiotic therapy according to the results from microbiology. There was no additional pancreatic leak among patients with grade A and B bile leak, as confirmed by the amount of pancreatic enzymes in the drainages. A grade C bile leak requiring relaparotomy was present in 7% (8/114) of patients (2% [1/55] in patients with a T tube vs 12% [7/59] in patients without a T tube, \( P = .036 \)). A bile leak from the hepaticojejunostomy was confirmed among all 8 patients during relaparotomy. Only 1 patient with a T tube underwent revisional operation of the hepaticojejunostomy. During relaparotomy, redo of the hepaticojejunostomy was impossible secondary to severe bleeding and adhesions. Therefore, in this patient, the hepaticojejunostomy was only drained. Conservative management was successful, and the patient was discharged after 43 days. Among the other 7 patients who underwent relaparotomy, 4 had anastomotic dehiscence at the ventral or lateral sites of the hepaticojejunostomy without ischemic necroses. Among all of these 4 patients, a T tube was placed into the hepaticojejunostomy through the site of the anastomotic dehiscence, and the anastomoses were oversewn. In 1 patient with complete dehiscence of the hepaticojejunostomy, the anastomosis was taken down and completely redone. Two patients with additional bleeding complications underwent salvage operations with external biliary diversion without a new anastomosis. One of these 2 patients also had a grade C pancreatic leak. During relaparotomy, this patient simultaneously underwent pancreatic remnant resection and splenectomy. Both patients finally died secondary to severe septic shock and delayed visceral hemorrhage. The mean time for the development of a bile leak was 15 ± 9 days (range 1 to 35 days) (17 ± 11 days for patients with T-tube drainage vs 14 ± 8 days for patients without T-tube drainage, \( P = .521 \)).

### Table 2 Operative procedures

<table>
<thead>
<tr>
<th></th>
<th>All patients (%)</th>
<th>T tube (%)</th>
<th>No T tube (%)</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>(N = 114)</td>
<td>48 (55/114)</td>
<td>52 (59/114)</td>
<td></td>
</tr>
<tr>
<td>PP Whipple</td>
<td>71 (81/114)</td>
<td>75 (41/55)</td>
<td>68 (40/59)</td>
<td>.427</td>
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<tr>
<td>Classic Whipple</td>
<td>11 (13/114)</td>
<td>9 (5/55)</td>
<td>14 (8/59)</td>
<td>.453</td>
</tr>
<tr>
<td>Total pancreatectomy</td>
<td>17 (19/114)</td>
<td>16 (9/55)</td>
<td>17 (10/59)</td>
<td>.933</td>
</tr>
<tr>
<td>Other</td>
<td>1 (1/114)</td>
<td>0 (0/55)</td>
<td>2 (1/59)</td>
<td>.332</td>
</tr>
</tbody>
</table>

*PP = pylorus preserving.*

### Table 3 Postoperative morbidity and mortality

<table>
<thead>
<tr>
<th></th>
<th>All patients (%)</th>
<th>T tube (%)</th>
<th>No T tube (%)</th>
<th>( P ) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td>(N = 114)</td>
<td>48 (55/114)</td>
<td>52 (59/114)</td>
<td></td>
</tr>
<tr>
<td>Mortality</td>
<td>5 (6/114)</td>
<td>4 (2/55)</td>
<td>7 (4/59)</td>
<td>.453</td>
</tr>
<tr>
<td>Morbidity*</td>
<td>53 (60/114)</td>
<td>55 (30/55)</td>
<td>51 (30/59)</td>
<td>.693</td>
</tr>
<tr>
<td>Major surgical complications</td>
<td>19 (22/114)</td>
<td>13 (7/55)</td>
<td>25 (15/59)</td>
<td>.086</td>
</tr>
<tr>
<td>Pancreatic fistula*</td>
<td>4 (5/114)</td>
<td>6 (3/55)</td>
<td>3 (2/59)</td>
<td>.591</td>
</tr>
<tr>
<td>Biliary leakage</td>
<td>12 (14/114)</td>
<td>9 (5/55)</td>
<td>15 (9/59)</td>
<td>.316</td>
</tr>
<tr>
<td>Intra-abdominal abscess</td>
<td>6 (7/114)</td>
<td>4 (2/55)</td>
<td>9 (5/59)</td>
<td>.282</td>
</tr>
<tr>
<td>Bleeding</td>
<td>7 (8/114)</td>
<td>4 (2/55)</td>
<td>10 (6/59)</td>
<td>.172</td>
</tr>
<tr>
<td>Wound dehiscence</td>
<td>1 (1/114)</td>
<td>2 (1/55)</td>
<td>0 (0/59)</td>
<td>.298</td>
</tr>
<tr>
<td>Other</td>
<td>1 (1/114)</td>
<td>0 (0/55)</td>
<td>2 (1/59)</td>
<td>.332</td>
</tr>
<tr>
<td>Major general complications‡</td>
<td>12 (13/114)</td>
<td>9 (5/55)</td>
<td>15 (9/59)</td>
<td>.316</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>4 (5/114)</td>
<td>4 (2/55)</td>
<td>5 (3/59)</td>
<td>.706</td>
</tr>
<tr>
<td>Cardiovascular morbidity</td>
<td>3 (3/114)</td>
<td>2 (1/55)</td>
<td>3 (2/59)</td>
<td>.600</td>
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<tr>
<td>Sepsis</td>
<td>4 (5/114)</td>
<td>6 (3/55)</td>
<td>3 (2/59)</td>
<td>.591</td>
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<tr>
<td>Other</td>
<td>3 (3/114)</td>
<td>0 (0/55)</td>
<td>5 (3/59)</td>
<td>.090</td>
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<tr>
<td>Minor surgical complications</td>
<td>18 (20/114)</td>
<td>24 (13/55)</td>
<td>12 (7/59)</td>
<td>.099</td>
</tr>
<tr>
<td>Delayed gastric emptying</td>
<td>9 (10/114)</td>
<td>13 (7/55)</td>
<td>5 (3/59)</td>
<td>.149</td>
</tr>
<tr>
<td>Wound infection</td>
<td>5 (6/114)</td>
<td>6 (3/55)</td>
<td>5 (3/59)</td>
<td>.930</td>
</tr>
<tr>
<td>Lymph fistula</td>
<td>5 (6/114)</td>
<td>7 (4/55)</td>
<td>3 (2/59)</td>
<td>.354</td>
</tr>
<tr>
<td>Minor general complications</td>
<td>14 (16/114)</td>
<td>16 (9/55)</td>
<td>12 (7/59)</td>
<td>.490</td>
</tr>
<tr>
<td>Cholangitis</td>
<td>8 (9/114)</td>
<td>9 (5/55)</td>
<td>7 (4/59)</td>
<td>.647</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>9 (10/114)</td>
<td>9 (5/55)</td>
<td>9 (5/59)</td>
<td>.907</td>
</tr>
</tbody>
</table>

*Four patients with a grade C fistula and 1 patient with a grade B fistula.
†One patient could have more than 1 postoperative complication.
Postoperative course of patients with a T tube

On T-tube imaging between the 5th and the 7th postoperative day, only 1 bile leak was documented. The T-tube remained unclamped for 7 days, and on reimaging there was no documented bile leak. In patients with regular T-tube imaging, T tubes were clamped for at least 6 weeks. There was no stenosis at the initial T-tube imaging.

Cholangiograms of the hepaticojejunostomy after 6 to 8 weeks revealed stenosis of the anastomosis in 4% (2/55) of patients. One of these patients initially had a bile leak grade B, whereas the other patient did not have postoperative complications. T-tube removal was uneventful in both patients. Both patients received ursodeoxycholic acid. On follow-up, a new hepaticojejunostomy was performed in the patient with former bile leak secondary to perforant cholangitis.

T-tube–associated complications

T-tube drainage–associated complications occurred in 15% (8/55) of patients. Seven percent (4/55) of patients developed cholangitis after T-tube removal. All 4 patients were successfully treated with antibiotics. Abdominal ultrasound did not reveal subhepatic collections, and no interventional procedures were required. In 7% (4/55) of patients, accidental T-tube dislocation occurred before the planned T-tube removal, but no patient developed biliary fistula or required antibiotic treatment or further interventions.

Comments

Outcome for patients with postoperative bile leaks

After pancreatic surgery, a bile leak is usually less threatening than a pancreatic fistula, and some authors do not even associate biliary leakage with morbidity or mortality. However, the present study clearly showed that bile leaks are associated with an increased risk for abscess formation, postoperative hemorrhage, sepsis, and mortality. Thus, the study showed that a bile leak is a life-threatening surgical complication negatively affecting perioperative and the long-term outcome.

Management of postoperative bile leaks

Bile leaks from the cut surface of the liver or from the common bile duct can be managed by interventional drainage via endoscopic retrograde cholangiography (ERC), whereas treatment of bile leaks from a hepaticojejunostomy is often difficult, requiring percutaneous drainage or even revisional laparotomy. Therefore, several new surgical procedures aimed at reducing the risk of postoperative bile leaks from the hepaticojejunostomy, especially in patients with a small common hepatic duct, have been developed. The goal of a T tube that is brought out through the anastomotic site of the hepaticojejunostomy in the presented trial was to reduce the rate of postoperative bile leaks among patients with a difficult hepaticojejunostomy. This has already been shown after liver transplantation although routine T-tube placement in patients undergoing liver transplantation remains controversial.

Prevention of postoperative bile leaks

After pancreatic head resection for pancreatic cancer, a T tube that is brought out through the anastomotic site of the hepaticojejunostomy is usually not required because most patients received preoperative biliary drainage secondary to obstructive jaundice. Endoscopic stenting leads to a dilation of the common hepatic duct with a thickened duct wall, which offers the opportunity to perform safe anastomosis.

However, the number of patients with pancreatic cancer in the presented trial was only 31%, whereas 49% of patients had benign or borderline periamplillary lesions. Among most other studies analyzing complications after pancreatic head resection, the rate of patients with malignancies is more than 60%. These differences are the result of the inclusion criterion for the study, which was a difficult hepaticojejunostomy secondary to a small common hepatic duct diameter or a thin common hepatic duct wall, which is more frequent among patients with benign diseases who did not undergo preoperative biliary drainage.

For patients with a difficult reconstruction after severe bile duct injuries or benign bile duct strictures, the placement of transanastomotic T tubes is a well-accepted technique. Therefore, reconstruction with a T tube is also an alternative for patients with a small and fragile common hepatic duct after pancreatic head resection.

Bile leaks after a difficult reconstruction

As expected, the overall rate of bile leaks in the present study was higher than recent results from the literature would suggest. It is important to point out that the increased rate of postoperative bile leaks in the present trial represents data of a group of highly selected patients who underwent a technically difficult hepaticojejunostomy at a specialized pancreatic center. Like in other centers, the rate of biliary leakage was much higher for patients with a difficult hepaticojejunostomy. During earlier studies at St. Josef Hospital, bile leaks occurred in only 1% (1/80), which is better than the results of most other centers. Therefore, a routine hepaticojejunostomy after pancreatic head resection is usually a safe procedure that does not require a T tube. Another explanation for the relatively high rate of bile leaks is that biliary leakage was defined according to the recent recommendations for pancreatic and liver surgery, whereas earlier studies used less severe criteria.
For the technique of a difficult hepaticojejunostomy, 7 interrupted sutures with polydioxanone 6/0 for each wall of the anastomosis were used. Although biliary reconstruction with wide interrupted sutures has also been reported for pediatric living donor liver transplantation, the technique in the present study was anastomosis with interrupted single sutures with 1-mm intervals, which is usually performed for the reconstruction of a small and fragile common hepatic duct in patients undergoing living donor liver transplantation. With the use of polydioxanone 6/0 sutures, there is usually enough space for 7 sutures in a row. Although we cannot rule out that the reconstruction of a small and fragile common hepatic duct with wide interrupted sutures may also achieve good results, the question of the present study was if the use of a T tube can reduce the rate of postoperative bile leaks in patients with a difficult hepaticojejunostomy after pancreatic head resection.

**Bile leaks after T-tube placement**

In this trial, the rate of bile leaks was 9% for patients with a T tube and 15% for patients without a T tube. T tubes did not reduce the incidence of bile leaks, but the incidence of postoperative hemorrhage and intra-abdominal abscess formation was higher for patients without T tubes. Patients without a T tube had a higher postoperative morbidity and required more reoperations. Thus, biliary diversion is important to reduce the rate of severe postoperative complications, which has already been shown for transhepatic drainage among patients with symptomatic biliary leakage after major upper gastrointestinal surgery.

Surprisingly, most bile leaks occurred in the late postoperative period. Only 1 bile leak was detected on routine postoperative T-tube imaging. Nevertheless, postoperative imaging of the hepaticojejunostomy through the T tube is useful. It enables an early detection of bile leaks that are the result of an error in surgical technique, originating from anastomotic dehiscence, whereas late bile leaks develop secondary to ischemic necrosis of the end of the common hepatic duct or local abscess formation. Early bile leaks can be managed either conservatively or by relaparotomy, whereas the treatment of late bile leaks is often complex, especially in association with delayed visceral hemorrhage. Therefore, morbidity and mortality associated with biliary leakage is affected by the late occurrence of biliary leakage, whereas early leakage is usually not associated with mortality.

**Advantages for the reconstruction with a T tube**

A T tube that is brought out through the anastomotic site of the hepaticojejunostomy lowers the pressure in the biliary system and offers immediate access to the biliary tree, enabling direct visualization of the anastomosis and bile aspiration for the identification of microorganisms responsible for postoperative cholangitis. In the present study, the rate of cholangitis was 8% (9/114), and the placement of a T tube was not associated with postoperative cholangitis, which has already been shown for patients who underwent liver transplantation. The initial antibiotic treatment was successful among all patients with acute cholangitis, which is certainly the result of a calculated antibiotic therapy that was chosen according to the result of the bile duct cultures routinely collected after bile duct transection during surgery.

The combination of bile with pancreatic juice is deleterious because the mixture is more aggressive eroding arterial vessel walls, resulting in consequent hemorrhage. In the present trial, the incidence of postoperative hemorrhage was higher for patients without T-tube drainage although there was only 1 patient with pancreatic and bile leak. Thus, delayed visceral hemorrhage also occurred without pancreatic fistula, which has already been shown. Even without the presence of a pancreatic fistula, biliary diversion through an unclamped T tube can help to drain off the potentially dangerous mixture of bile with bacterial enzymes, which has already been shown by external biliary diversion through percutaneous drainage.

**T-tube–associated complications**

The most common complications associated with a T tube are cholangitis, biliary leakage after T-tube removal, accidental dislocation, electrolyte disturbances, and dehydration secondary to inadequate water ingestion or high outflow, especially in elderly patients. In the literature, the rate of bile leaks after T-tube removal after liver transplantation varies between 5% and 33%, whereas it is 6% after choledochotomy. During the study, no patient developed biliary leakage after T-tube removal. This might be related to the position of the T tube that is brought out through the site of the anastomosis of the hepaticojejunostomy, where bile leaks are less common. Furthermore, the period before T-tube removal was 6 to 8 weeks, whereas biliary leakage is more common if T tubes are already removed earlier. Substantial electrolyte disturbances or dehydration did not occur during the study. Four patients had accidental T-tube dislocation, but none of those 4 patients required active therapeutic intervention. Thus, T-tube–associated complications were less common than suggested by former reports.

**Limitations**

The present study has several limitations. First of all, this was a retrospective trial that analyzed the rate of bile leaks with or without a T tube during 2 different time periods. The surgical technique might have improved during the study with a reduction of bile leaks for patients who had reconstruction with a T tube during the 2nd episode of the study. This might have contributed toward the lower rate of bile leaks among patients with a T tube. Nevertheless, surgical
morbidly and especially the rate of pancreatic fistula did not change during the study.

The definition of a difficult hepaticojejunostomy is questionable. Technical difficulties are certainly the cause for the higher rate of bile leaks in patients with obesity or anastomosis at the segmental bile ducts, whereas chemotherapy, radiation, or former surgical interventions and preoperative biliary drainage lead to fibrosis with impaired healing of the anastomosis.2,3 In the literature, several trials report on their results for the reconstruction of a difficult hepaticojejunostomy; however, only a few studies give an exact definition of a small common hepatic duct diameter.12–21 The inclusion criteria in the present trial were a common hepatic duct diameter of 5 mm or less or a thin common hepatic duct wall requiring reconstruction with polydioxa- none 6/0, whereas in the literature criteria for a difficult hepaticojejunostomy secondary to a small common hepatic duct diameter range between 1 and 9 mm.23–24,41,42

Actually, there is no long-term follow available analyzing the rate of strictures of the hepaticojejunostomy. The rate of biliary stricture formation after pancreatic head resection is 3% and ranges between 12% and 19% after liver transplantation, which is certainly more representative for a difficult anastomosis.3,43 On T-tube imaging, 4% (2/55) of patients had a stricture of the anastomosis, but only 1 patient required revisional surgery. The rate of biliary strictures for patients with a T tube was low, which has also been shown on long-term follow-up for patients who underwent liver transplantation.17

Although the present trial did not analyze other risk factors for postoperative biliary leakage, it did show that bile leaks are more frequent in patients with a small common hepatic duct diameter or a thin common hepatic duct wall. A T tube was not able to prevent the presence of a bile leak, but morbidity from biliary leakage was less severe in patients with biliary diversion through the T tube.

Conclusions

Patients with a small common hepatic duct diameter or a thin duct wall have a high risk for bile leaks from the hepaticojejunostomy. A T tube that is brought out through the anastomosis cannot prevent biliary leakage, but postoperative morbidity from bile leaks is less severe, resulting in less reoperations. Thus, a T tube should be considered in patients with difficult hepaticojejunostomy.

References