Selection of Pancreaticojejunostomy Techniques According to Pancreatic Texture and Duct Size

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Hypothesis: Selection of proper pancreaticojejunostomy techniques according to pancreatic texture and the main duct size reduces the pancreatic fistula rate.

Design and Patients: Data from 50 consecutive patients undergoing pancreatoduodenectomy with 3 different anastomotic techniques prospectively used according to pancreatic texture and the main duct size were analyzed. Duct-invagination anastomosis was selected for pancreata with a small duct (n = 34 [29 with a soft texture and 5 with a hard texture]). Stitches between the stump parenchyma and the jejunal seromuscular layer were added to this anastomosis procedure only for the hard pancreata. Pancreata with a large duct were reconstructed with a conventional duct-to-mucosa anastomosis (n = 16).

Setting: A university hospital department of digestive surgery.

Results: The morbidity was 40% (20 of 50 patients) in this series. Four patients (8%) with a soft pancreas and a small duct developed a pancreatic stump leak after duct-invagination anastomosis, but all of them were removed without sequelae. No pancreatic anastomotic leak was seen in this series, which resulted in no mortality, no remnant pancreatectomy, and only 1 relaparotomy in the consecutive 50 patients.

Conclusion: The proper selection of pancreatic reconstruction techniques according to our criteria may reduce the pancreatic fistula rate, eliminate risky pancreatic anastomotic leaks, and result in excellent outcomes for those undergoing pancreatoduodenectomy.

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In recent years, pancreatoduodenectomy has been performed with an operative mortality of less than 5% in many large-volume centers. However, this operation is still associated with a high incidence of postoperative morbidity, approaching 50%. A pancreatic fistula is the most important complication, from which approximately 80% of patient deaths result. The incidence of a pancreatic fistula varies from 5% to 25% in most series. A recently published article of a large series of pancreatic resections demonstrated that this incidence did not change in the past decade.

See Invited Critique at end of article

Because the definition of pancreatic fistula has not been standardized, most series included pancreatic-enteric anastomotic leaks (pancreatic anastomotic leaks [ALs]) and extravasation of pancreatic secretions from the pancreatic stump (pancreatic stump leaks [SLs]) as pancreatic fistulas. An AL is a risky complication that possibly leads to life-threatening complications, including pancreatic abscesses, subsequent sepsis, and massive hemorrhage, because this pancreatic fistula is activated by a concomitant leak of the enteric contents. In contrast, an SL is usually clinically unimportant and can be removed without sequelae. Therefore, distinctive analysis of these 2 pancreatic fistulas and prevention of ALs are important.

In an attempt to prevent pancreatic fistulas, we prospectively used 3 different anastomotic techniques according to pancreatic texture and the main duct size since November 30, 1998. In the present study, we report the results of our 50 consecutive pancreatoduodenectomies.

PATIENTS AND METHODS

Patients

Between November 30, 1998, and September 6, 2001, 50 consecutive patients underwent standard Whipple resection (n = 31) or pylorus-preserving pancreatoduodenectomy (n = 19) at
The duct-invagination technique was chosen. Details of the jejunal loop for a follow-through radiographic study (Urografin) was introduced through a transanastomotic bile stent on postoperative day 7, regardless of the discharge volume. In this series, 20 (40%) of the patients had diabetes mellitus preoperatively. The median preoperative serum albumin and total cholesterol levels in these 50 patients were 3.4 g/dL (range, 1.4-3.8 g/dL) and 168 mg/dL (4.34 mmol/L) (range, 35-298 mg/dL [1.42-7.71 mmol/L]), respectively.

SURGICAL PROCEDURES

All surgical procedures were performed by 2 senior surgeons (Drs Suzuki and Kuroda). The pancreas was transected using an ultrasonic dissector (CUSA System; Cooper Medical Devices Corp, Mountainview, Calif) at the lowest vibration level in all patients. The principle of ultrasonic dissection is as follows: crushing the parenchyma with differentiation and preservation of nonparenchymal tissue, including branch ducts and small blood vessels, based on their water content differences. Therefore, the fibrotic pancreas is relatively hard to transect. Based on the difficulty or ease of the ultrasonic dissection, the pancreata were divided into 2 groups (soft texture and hard texture).

Reconstruction was achieved using 1 jejunal loop with an end-to-side pancreaticojunostomy, an end-to-side hepaticojejunostomy, and a gastrojejunostomy, according to the Child procedure. A transanastomotic catheter was placed in the pancreatic duct in all patients. Pancreatic anastomoses were created using 3 different techniques. The strategy of pancreatic transection and reconstruction is shown in Figure 1. For 29 pancreata with a soft texture and a small duct (diameter, ≤5 mm), the duct-invagination technique was chosen. Details of this unique technique are shown in Figure 2. During transection with an ultrasonic dissector, even branch pancreatic ducts were identified, ligated, and divided. The main duct was easily exposed (>1 cm), and a small-caliber pancreatic catheter was inserted into the duct and fixed with 2 absorbable suture ligations. Subsequently, pancreatic duct invagination could be easily performed through a 10-gauge intravenous catheter passed through the jejunum. The main duct was anchored to the adjacent serosa, and 3 mL of fibrin glue was sprayed to the pancreatic stump. No pancreatic parenchymal stitches were placed during the procedures. For pancreata with a hard texture and a small duct (n = 5), this duct-invagination anastomosis was performed in the same way but followed by placing stitches between the stump parenchyma and the jejunal seromuscular layer. Meanwhile, pancreata with a dilated duct (diameter, >5 mm) (n = 16), all of which had a hard texture, were reconstructed with a hand-sewn duct-to-mucosa technique with 8 to 12 interrupted stitches of 5-0 or 6-0 polydioxanone absorbent monofilament sutures and a 2-layer anastomosis.

POSTOPERATIVE MANAGEMENT AND ASSESSMENTS

Intravenous hyperalimentation and protease inhibitors were routinely used perioperatively in all patients in this series. Erythromycin lactobionate and octreotide were not administered.

The level of fluid amylase from a closed drain placed near the pancreatic anastomosis was determined on days 1 and 7. A pancreatic fistula was diagnosed when the fluid amylase concentration was greater than 3 times the serum concentration on postoperative day 7, regardless of the discharge volume. In patients with a pancreatic fistula, 20 mL of contrast medium (Urografin) was introduced through a transanastomotic bile stent into the jejunal loop for a follow-through radiographic study to rule out AL. Unless an intraperitoneal leak of the contrast medium around the pancreaticojunostomy site was seen, the pancreatic fistula was considered an SL, not an AL.

The median (range) operative time and blood loss were 515 (285-975) minutes and 1215 (312-5050) mL, respectively. Four patients (8%) developed a pancreatic fistula in this series (Table). All of these patients underwent the duct-invagination procedure for reconstruction of their soft pancreases and had a small duct (4 [14%] of 29 patients). No pancreatic fistula was seen in the patients with a hard pancreas. The fistulas seen in this series, however, were all SLs and were removed without sequelae within 21 days. No ALs were seen in this series. As a result, no remnant pancreatectomy was performed among the 50 patients. Only 1 patient underwent a relaparotomy on day 1 for postoperative bleeding; the other 49 patients were discharged from the hospital without a relaparotomy. There was no in-hospital mortality.

Other complications included 6 wound infections (12%), 4 cases of cholangitis (8%), 3 bile leaks (6%), 3 cases of delayed gastric emptying (6%), 2 liver abscesses (4%), 2 intraperitoneal abscesses (4%), and 1 gastrojejunostomy ulcer (2%). The morbidity was 40% (20 of 50 patients) in this series.

COMMENT

The incidence of pancreatic fistula varies from 5% to 25% after pancreatectoduodenectomy in most series. Among the pancreatic fistulas, ALs caused by disruption between the pancreatic main duct and the jejunum can lead to serious sequelae, including pancreatic abscesses, subsequent sepsis, and massive hemorrhage. Several published studies enrolled ALs and SLs (which are extravasations of pancreatic secretions from the pancreatic stump into the pancreatic fistula), presumably because their differential diagnosis is difficult in many cases. In studies that defined the pancreatic fistula as the persistent drainage of more than 30 or 50 mL/d of amylase-rich fluid after postoperative day 7 or 10, respectively, pancreatic fistulas are thought to include considerable percentages of ALs because most SLs are expelled from the pancreatic fistula group. In fact, none
of our 4 fistulas discharged more than 50 mL/d of fluid. On the other hand, if a more liberal definition is used, eg, fluid discharge with an amylase concentration of more than 3 times the serum concentration regardless of the discharge volume, even a clinically unimportant SL that can be removed without sequelae belongs to a category of pancreatic fistulas. In this study, we tried to diagnose these 2 pancreatic fistulas distinctively by jejunal loop fluoroscopy with contrast medium introduced through a bile duct stent. However, no AL was diagnosed in our 50 consecutive pancreatoduodenectomies, and only 4 SLs were detected, which spontaneously closed in a short period.

Reconstruction of soft pancreata is strongly associated with a pancreatic fistula. Recent data from The Johns Hopkins Hospital, Baltimore, Md, demonstrated that the pancreatic fistula rate was 0% for those with a hard pancreas and 25% for those with a soft pancreas. Also, in our series, all 4 pancreatic fistulas developed in the soft texture group (14% of 29 patients). This may be interpreted by 3 risk factors of the soft pancreas. First, most soft pancreata have a small duct, in which secure duct-to-mucosa anastomosis is difficult. Second, a soft pancreas is more easily injured directly or via ischemia by stitches placed between the pancreatic cut end and the seromuscular layer of the digestive tract. Third, a soft pancreas has a good exocrine function, secreting more pancreatic juice rich in proteolytic enzymes.

The key to excellent outcomes after pancreatoduodenectomy is certainly a reduction in the incidence of ALs. To reduce risky ALs for soft pancreata with a small duct, we developed a duct-invagination anastomosis technique. This easy technique can be completed in less than 10 minutes and does not need experienced hands. We filled up the space between the pancreatic stump and the jejunal serosa with 3 mL of fibrin glue to avoid injury or ischemia of the stump, possibly caused by the parenchyma stitches. However, 4 SLs eventually occurred in this group. Although this incidence (4 [14%] of 29) after soft pancreas reconstruction was not high, placing stitches between the stump parenchyma and the jejunal seromuscular layer instead of fibrin glue sealing should be examined in a further study. On the other hand, for pancreata with a hard
texture, we placed tight silk stitches between the stump parenchyma and the jejunal seromuscular layer following this invagination procedure, because these stitches rarely induce internal laceration or ischemia in such pancreata and because the ultrasonic dissection is relatively difficult for a hard texture and, thus, secure ligation of branch ducts tends to be uncertain. Meanwhile, invagination of a dilated main duct through a 10-gauge intravenous catheter is technically difficult or impossible. A catheter larger than 10-gauge is not commercially available. Therefore, the conventional duct-to-mucosa anastomosis is considered the most suitable procedure for fibrotic pancreata with a large duct for which the anastomosis can be performed easily. In this prospective trial with selection of pancreaticojejunostomy techniques according to pancreatic texture and duct size, no ALs occurred in a consecutive series of 50 pancreatoduodenectomies in the 1990s, which was not associated with a pancreatic fistula.

Our duct-invagination technique required and used total extracorporeal drainage of the pancreatic juice during the postoperative course. The separation of pancreatic juice from the jejunal contents prevents its activation and keeps the rest of the anastomosis. The stent drainage catheter can be easily removed 4 to 5 weeks after the operation when we consider that stabilization of the anastomosis is achieved. No serious complication occurred after its removal, except transient serum amylase elevation was noted in several patients. Moreover, neither remnant pancreatitis nor serious exocrine deteriora-

tion was observed during follow-up observation periods in the 34 patients undergoing duct-invagination anastomosis. The total pancreatic juice drainage for a prolonged period necessitates close observation and proper management of the catheter. In 2 patients in this series, the catheter obstruction occurred during the first postoperative week at a site where the catheter was fixed to the skin. Although these catheters were reopened immediately after suture removal, one resulted in an SL. In the other 48 patients, 100 to 500 mL of pancreatic juice steadily exteriorized through the catheter throughout the postoperative course.

Pancreatoduodenectomy has been considered a formidable operation. We consider simply that prevention of ALs likely results in excellent outcomes of this operation and makes this operation as safe as other abdominal surgical procedures. Our selection of the proper pancreatic anastomotic techniques according to pancreatic texture and duct size may reduce the pancreatic fistula rate, eliminate risky ALs, and result in excellent outcomes for those undergoing pancreatoduodenectomy.

### Vacuum Drainage

Vacuum drainage catheters are mandatory in pancreatoduodenectomy and choledochojejunostomy. In the 42 patients who underwent choledochojejunostomy, the drainage catheter was kept for a mean of 10 days. The drainage catheter was removed after 2 days in 1 patient because of drainage of 150 mL of bloody fluid. This patient was successfully treated by reinsertion of the drainage catheter. We consider the use of a drainage catheter as a useful tool to evaluate the activity of the pancreatic juice and to keep the rest of the anastomosis. The stent drainage catheter can be easily removed 4 to 5 weeks after the operation when we consider that stabilization of the anastomosis is achieved.

### Case Report

A 58-year-old male who had been suffering from chronic pancreatitis for 10 years underwent a left pancreatectomy. The patient had been in bed for 10 days after the operation when a 20-gauge intravenous catheter that was fixed to the skin was re-opened immediately after suture removal. The stent drainage catheter was reinserted 4 days after re-opening and the drainage fluid was bloody for 2 days. The patient was discharged 12 days after the operation. There was no recurrence of pancreatitis or other complications. The patient is now well 13 years after his operation.

### Table: Frequency of a Pancreatic Fistula (SL) Relating to Pancreatic Texture and Duct Size

<table>
<thead>
<tr>
<th>Variable</th>
<th>Soft and Small</th>
<th>Hard and Small</th>
<th>Hard and Large</th>
<th>Total</th>
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<td>Disease</td>
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<tr>
<td>Pancreas cancer</td>
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<td>0/3</td>
<td>0/6</td>
<td>0/11</td>
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<td>0/1</td>
<td>1/10</td>
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<td>Cystic tumor</td>
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<td>0/2</td>
<td>1/9</td>
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<tr>
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<td>0/1</td>
<td>0/5</td>
<td>0/8</td>
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<tr>
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<td>0/2</td>
<td>1/5</td>
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<tr>
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<tr>
<td>Surgical procedure</td>
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<tr>
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<td>0/4</td>
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<td>PpPD</td>
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<td>0/1</td>
<td>0/1</td>
<td>3/19</td>
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<tr>
<td>Total†</td>
<td>4/29 (14)</td>
<td>0/5</td>
<td>0/16</td>
<td>4/50 (8)</td>
</tr>
</tbody>
</table>

*Data are given as number of patients/total in that category. SL indicates stump leak; PD, Whipple resection; and PpPD, pylorus-preserving pancreatoduodenectomy.
†Data in parentheses are percentage of patients.

### REFERENCES