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Pylorus-preserving pancreatoduodenectomy – technical aspects

J. W. Braasch and M. Gagner*

Department of General Surgery, Lahey Clinic Medical Center, Burlington, MA, USA

Technische Aspekte der pyloruserhaltenden Pankreatoduodenektomie

Zusammenfassung. Die pyloruserhaltende Pankreatoduodenektomie ist die Resektionsmethode der Wahl bei Patienten mit einem Karzinom des Pankreaskopfes und der periampullären Region und bei einigen Patienten mit chronischer Pankreatitis. Präoperative Vorbereitung, Operationstechnik und Ergebnisse werden besprochen.

Schlüsselwörter: Pankreasresektion – Periampulläres Karzinom – Chronische Pankreatitis – Pyloruserhaltende Pankreatoduodenektomie – Pankreaskarzinom

Summary. Pylorus-preserving pancreatoduodenectomy is the resection of choice for patients with carcinoma of the head of the pancreas and periampullary area and for certain patients with chronic pancreatitis. Preoperative preparation, operative technique, and results are discussed.

Resections of the entire pancreas or portions of it have interested surgeons for almost 100 years. However, because of its retroperitoneal location in an area of complex vascular anatomy and because of the inherent difficulty with anastomosis, technical progress with resective operations on the pancreas has been slow. However, recent improvements in technique have reduced the mortality rate, making pancreatoduodenectomy the last major abdominal operative procedure to achieve a postoperative mortality rate of 5% or less.

Although in the early 20th century, isolated reports [30] appeared of resection of portions of the entire head of the pancreas in individual patients, until 1936, no surgeon had as many as three reported experiences with resection, and results of successful resection were few. In that year, Whipple et al. [61] reported on three patients with carcinoma of the ampulla of Vater treated by resection of a portion of the head of the pancreas (Fig. 1). With this technique, the exocrine pancreas was oversewn, and although the pylorus was preserved, gastrojejunostomy was performed. By 1941, Hunt [24] catalogued the multiple varieties of reconstruction performed after resection of the head of the pancreas, and Brunchwig [6] expanded resection to include the entire head of the pancreas. It became apparent after reports from the Mayo Clinic [36] and the Lahey Clinic [59] that most postoperative complications were caused by leakage at the pancreatic anastomosis or at the oversewn end of the pancreas. Thus, infection and hemorrhage occurred after pancreatoduodenectomy all too often. With refinements in the technique of resection and pancreatic anastomosis [4, 8, 9, 56], reports [5, 11, 15, 18, 22, 27, 37, 39, 52, 54, 55, 57] of improvement in postoperative mortality appeared in the literature, and earlier attention could be directed to possible improvement in nutrition and the use of the operation for the treatment of patients with benign lesions as well as periampullary neoplasms.

Independently, Watson [60] and Traverso and Longmire [53] resected the head of the pancreas and preserved the pylorus and the stomach. These surgeons assumed that this variation of the standard procedure would retain the mixing function of the stomach, prevent dumping, and lessen the subclinical malnutrition that occurs after gastric resection [62]. An additional benefit would be a decrease in operating time with use of a simpler operation that avoids gastric resection with or without truncal vagotomy. It was hoped that, when this procedure was applied to patients with periampullary neoplasms, preservation of the antrum of the stomach, pylorus, and the first centimeter of duodenum would not jeopardize the chance for cure because only a minimal amount of tissue that might harbor metastases from the tumor surrounded these preserved structures. Our interest in this procedure began in 1979 and has continued to date.

* *Present address:* Department of Surgery, University of Montreal, Montreal, Quebec, Canada
Reprint requests: J. W. Braasch, M. D., Department of Surgery, Lahey Clinic Medical Center, 41 Mall Road, Burlington, MA 01805, USA

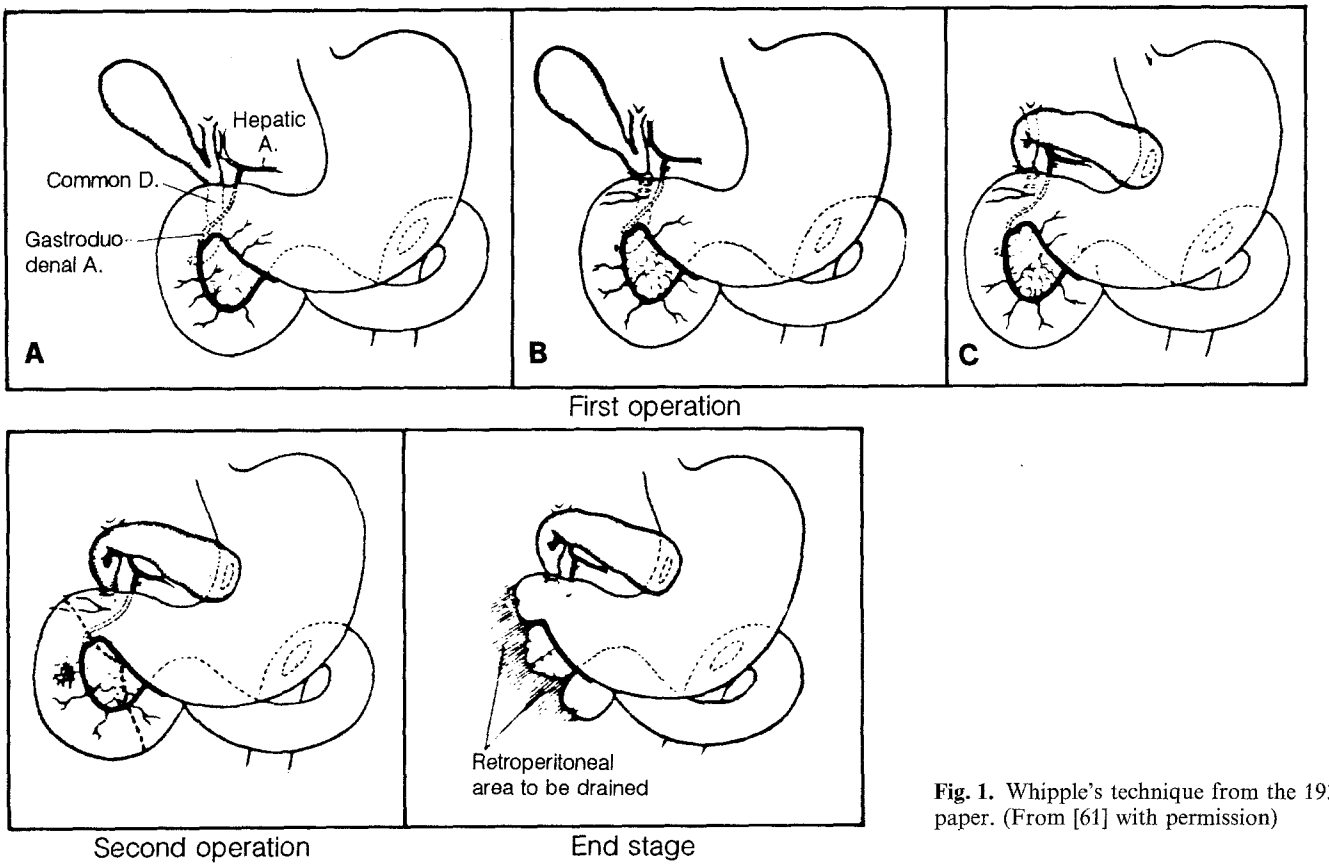

Fig. 1. Whipple's technique from the 1935 paper. (From [61] with permission)

Indications

Pylorus-preserving pancreatoduodenectomy is useful in patients with chronic pancreatitis, recurrent subacute pancreatitis, pancreatic neoplasms, and primary tumors of the duodenum, distal bile duct, and ampulla of Vater. The procedure can also be used as a diagnostic resective procedure in patients in whom the likelihood of neoplasm is high, such as in patients with carcinoma of the distal bile duct or pancreas and in whom obtaining a specimen positive on biopsy is difficult.

Patients who are massively obese, patients with respiratory disease severe enough to limit pulmonary reserve, patients with an unstable cardiovascular system, and other patients who are generally debilitated are at much higher risk for complications from this procedure. Most patients at high risk are older than 70 years of age (Gagner M, Rossi RL, Braasch JW. Unpublished data, 1990). The decision to use this procedure is made on an individual basis in high-risk patients when a high cure rate is expected.

Preoperative care

Use of preoperative endoscopic intubation of biliary tract obstruction or percutaneous transhepatic biliary drainage for better preparation of the patient for major resection is controversial. Prospective blinded trials [10, 17, 20, 35, 41, 49] comparing results with and without drainage in patients with relatively low levels of preoperative blood bilirubin and lengths of decompression measured in days have failed to show a difference in morbidity and mortality. Before employing preoperative biliary drainage, the surgeon should keep in mind the risk of infection, hemorrhage, and slippage of tubes [29, 44].

Surgical technique

Pancreatoduodenectomy is performed in the right upper quadrant of the abdomen; therefore, access to this area is best obtained by either a high right vertical abdominal incision or by a bilateral subcostal incision with possible vertical extension to the xiphoid process. Our preference is a right vertical rectus muscle-splitting incision that permits retraction of the transverse colon and omentum to the left and retraction on the abdominal wall by a rigid retracting system, such as the Bookwalter retractor (Codman & Shurtleff, Inc., Randolph, MA, USA).

Several steps are required for assessment of the resectability of a benign or malignant periampullary lesion. Examination of the abdomen for distant metastatic disease is the first procedure, followed by cholecystectomy. Next, the foramen of Winslow should be opened, and an extended Kocher maneuver should be performed (Fig. 2) over to the left side of the abdominal aorta. The lesser sac is opened by severing the gastrocolic ligament, and the fused area just medial to the second portion of the duodenum is separated. These maneuvers permit access for bi-

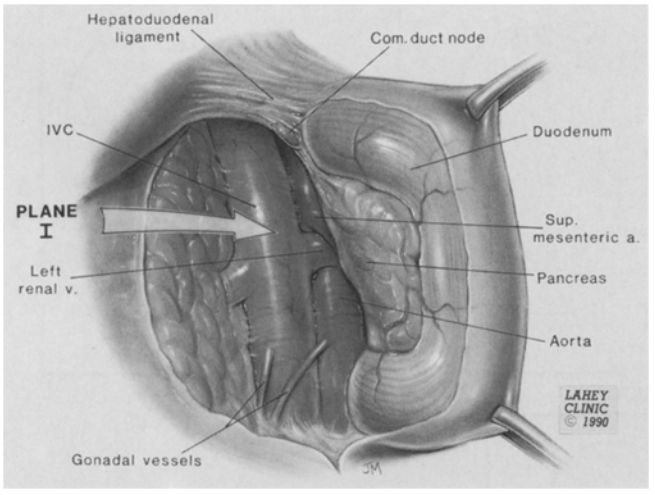

Fig. 2. *Plane I:* Extended Kocher maneuver (by permission of Lahey Clinic)

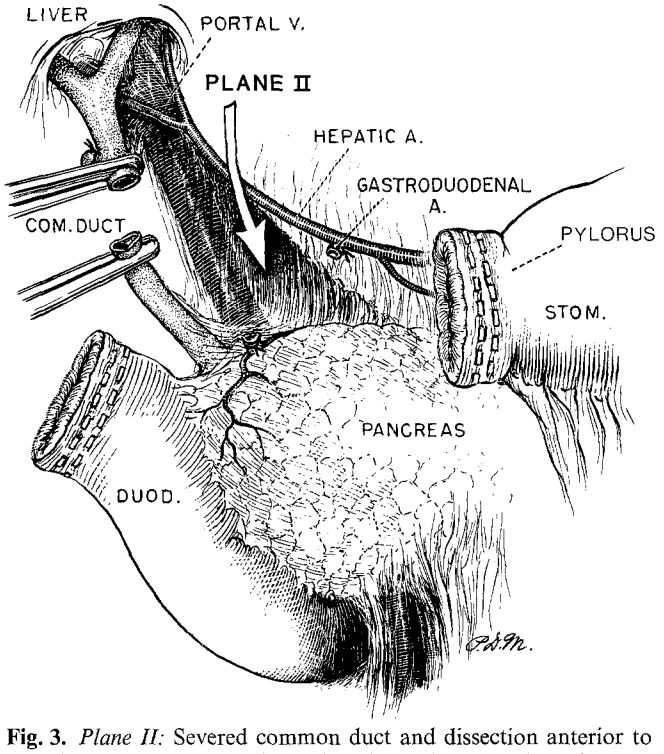

Fig. 3. *Plane II:* Severed common duct and dissection anterior to portal vein. (From Braasch JW (1987) Surgical resection of cancer of the midduct and distal common bile duct: the Lahey Clinic experience. In: Wanebo HY (ed) Hepatic and biliary cancer. Dekker, New York, p 367, with permission)

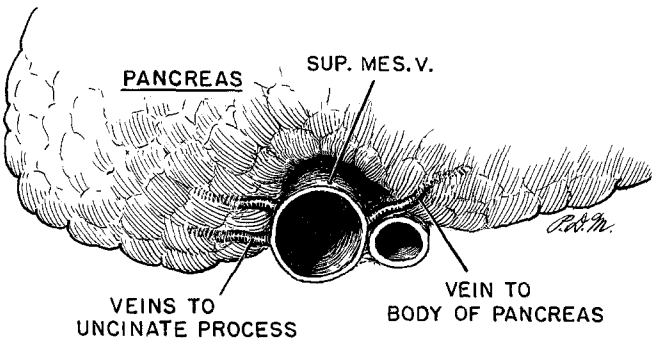

Fig. 4. *Plane III:* Space under neck of pancreas anterior to superior mesenteric vein is suitable for dissection. (From Braasch JW, Gray BN (1976) Technique of radical pancreatoduodenectomy: with consideration of hepatic arterial relationships. Surg Clin North Am 56:637, with permission)

manual palpation of the head of the pancreas, duodenum, ampulla of Vater, and distal bile duct and permit examination and biopsy of the common bile duct node, gastroduodenal node, periaortic nodes, and nodes of the celiac axis. The extent of direct tumor extension toward the hepatic artery superiorly or toward the superior mesenteric artery and vein inferiorly and medially can be determined. In general, patients with primary carcinoma of the distal bile duct, ampulla of Vater, or duodenum should have aggressive surgical resection in the presence of positive nodes when the node groups can be included in the resection. For patients with carcinoma of the pancreas, the tumor must not infiltrate outside of the pancreas toward the celiac axis or the superior mesenteric artery, and we prefer negative nodes before the lesion is resected.

Invasion of the portal or superior mesenteric vein is difficult to ascertain in some patients. Additional information can be obtained by severing the common bile duct (with care to preserve any posteriorly placed replaced hepatic artery) and dissecting anterior to the portal vein down to the neck of the pancreas and in so doing ligating and severing the gastroduodenal artery (Fig. 3). At this point, a finger can be inserted under the neck of the pancreas with ease in the avascular plane (Fig. 4). If bimanual palpation with a hand posterior to the head of the pancreas and a finger under the neck of the pancreas fails to suggest invasion of the vein, the surgeon can proceed with resection. Resection of the vein in patients with carcinoma of the pancreas is not desirable when invasion of the vein is found. The procedure can be terminated at this point with biliary bypass with or without gastric bypass or with palliative resection, including a side or segment of vein.

When resection is possible, three of the four planes necessary for resection have already been dissected. Kocher's maneuver is plane I, dissection lateral to the hepatic artery and anterior to the portal vein is plane II, and dissection under the neck of the pancreas is plane III. Only dissection of plane IV, which is lateral to the superior mesenteric vein superiorly up to the neck of the pancreas, remains (Fig. 5).

The arterial blood supply to the first part of the duodenum is through the supraduodenal artery, which arises from the proper hepatic artery. No right gastric artery exists in most patients, but some of the arterial supply to this part of the duodenum must come from the left gastric and right gastroepiploic arteries. When possible, it is desirable to preserve the supraduodenal artery, but its preservation might, at times, produce difficulties because of kinking of the duodenojejunal anastomosis. In some patients, severance of the supraduodenal artery leads to an undesirable color of the proximal duodenal segment; however, in these patients, anastomosis is performed

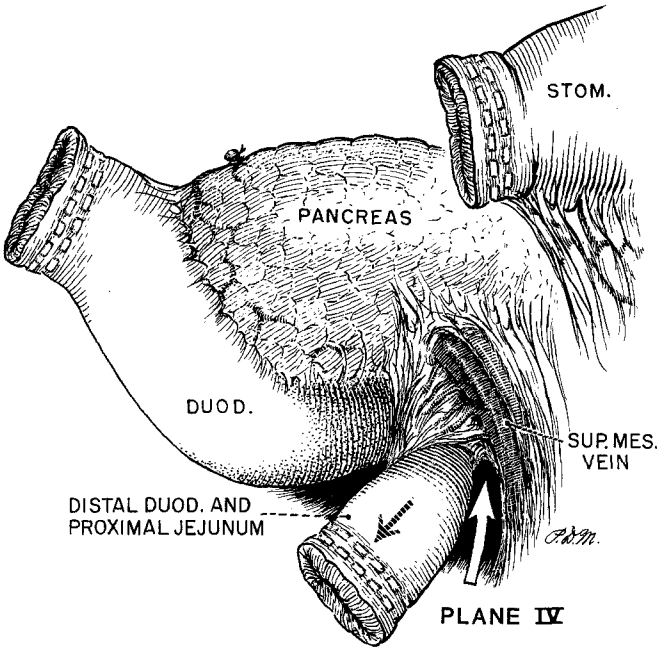

Fig. 5. *Plane IV:* Dissection lateral to superior mesenteric vein. (From Braasch JW (1987) Surgical resection of cancer of the mid-duct and distal common bile duct: the Lahey Clinic experience. In: Wanebo HY (ed) Hepatic and biliary cancer. Dekker, New York, p 367, with permission)

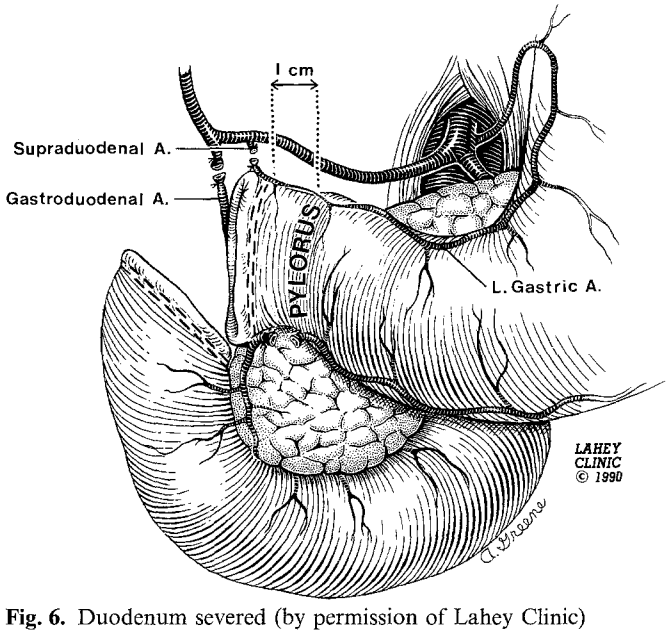

Fig. 6. Duodenum severed (by permission of Lahey Clinic)

close to the pylorus, and we have not experienced leakage from the duodenojejunostomy.

Conceivably, the length of the duodenum remaining could influence duodenal hormonal function [25, 45, 51] with regard to gastric and pancreatic secretion and also pyloric function. However, the critical limits of the length of the duodenum have not been established.

The duodenum can be severed at this time with a GIA stapling machine (United States Surgical Corp., Norwalk, CT, USA) 1 cm distal to the pylorus (Fig. 6). The third part of the duodenum can be the limit of distal resection for small tumors of the ampulla of Vater or distal bile duct or in patients with chronic pancreatitis when end-to-side pancreatojejunostomy is to be the pancreatic reconstruction of choice. When a dunking anastomosis, end of pancreas into open-ended jejunum, is required, the jejunum must be severed 12–15 cm distal to the ligament of Treitz and the proximal jejunum passed back underneath the superior mesenteric vessels to the right upper quadrant. These maneuvers permit dissection of the mesentery of the duodenum and the uncinate process from the superior mesenteric vein proceeding superiorly to the inferior surface of the pancreas.

The neck of the pancreas is then severed over the midportion of the portal vein or farther to the left to permit the removal of more pancreas and a more central placement of the pancreatic duct for the pancreatic anastomosis. The head and the neck of the pancreas, main portion of the duodenum, and distal bile duct are excised from their connection by small veins directly to the portal vein and superior mesenteric vein and by arteries to the posterior pancreatoduodenal arcade.

Hemostasis should now be completed, and a final decision is made regarding the type of pancreatic anastomosis to be created. When the pancreas is firm as a result of obstructive pancreatitis or chronic pancreatitis, an end-to-side two-layer anastomosis can be used. This is somewhat easier when the pancreatic duct is large, but the size of the pancreatic duct is not crucial. When the pancreas is soft and the duct is small, a dunking procedure is best.

The superior and inferior longitudinal pancreatic arteries have been secured by suture ligatures. The end of the pancreas must be freed up for about 2 cm before the anastomosis is attempted, and any bleeding must be controlled by electrocoagulation or by placement of interrupted sutures. Fine permanent sutures are placed in the posterior lip of the pancreatic duct (Fig. 7). The loop of jejunum is brought adjacent to the end of the pancreas, and a tiny stab wound is made in the antimesenteric border, which will be the site of the duct anastomosis. A pancreatic feeding tube for small ducts or a small red rubber catheter for larger ducts is passed through the abdominal wall, through the jejunal loop to be used for anastomoses, and out the stab wound in the jejunal loop. Permanent interrupted sutures approximate the posterior capsule of the pancreas and the posterior aspect of the jejunal loop near the stab wound. These sutures are tied, and then the sutures placed posteriorly in the duct are continued through the posterior aspect of the stab wound and tied. The pancreatic tube stent is placed into the pancreatic duct and secured in place with a suture. The anterior aspect of the duct anastomosis is completed (Fig. 8) as is the approximation of the anterior capsule of the pancreas to the serosal muscularis layer of the jejunal loop.

When the pancreas is soft and the pancreatic ducts are small, a dunking anastomosis is preferred (Fig. 9). Suture ligatures on the upper and lower edge of the pancreas are established, and these draw the pancreas into the open end of jejunum. Circumferential sutures join the pancreatic capsule to the serosal muscularis layer of the jejunum.

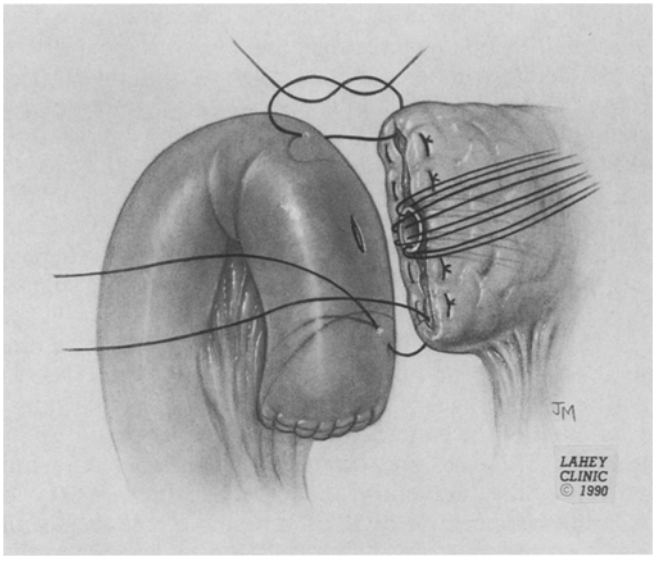

Fig. 7. End-to-side pancreaticojejunostomy; initial stage (by permission of Lahey Clinic)

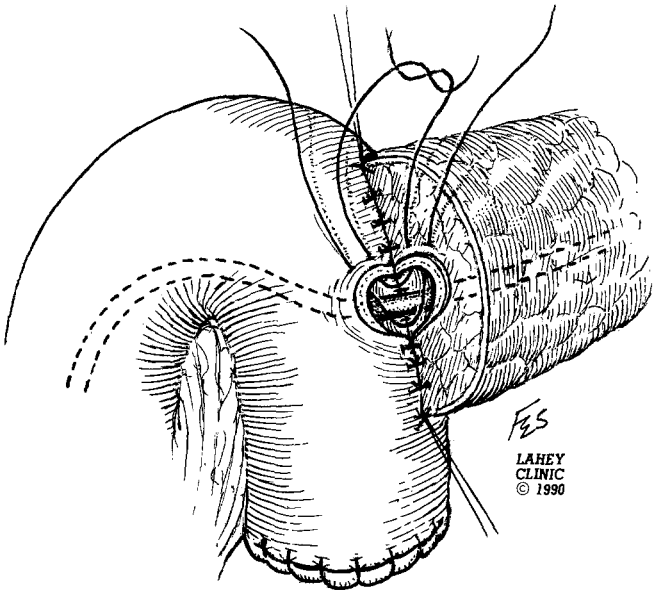

Fig. 8. Anterior portion of pancreatic duct anastomosis (by permission of Lahey Clinic)

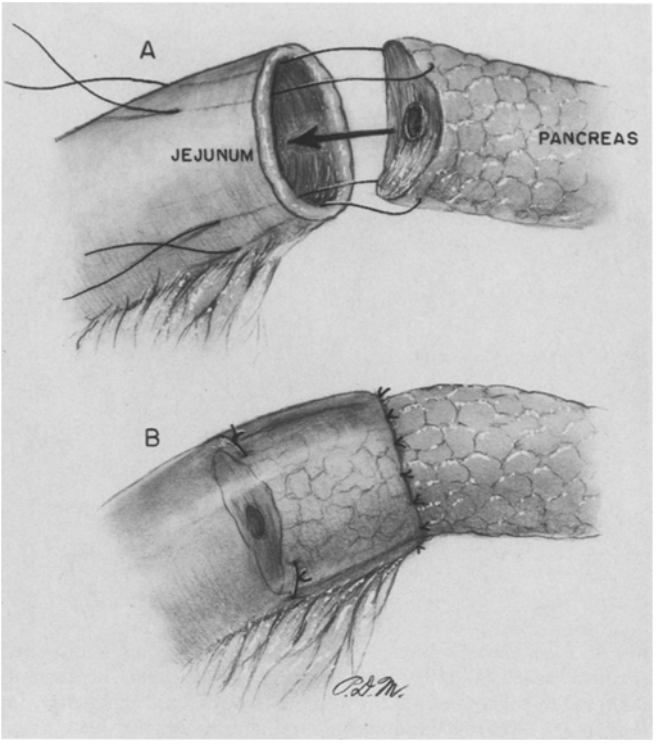

Fig. 9 A, B. Dunking pancreaticojejunostomy. **A** Before insertion of pancreas. **B** Completed anastomosis. (From Braasch JW (1983) Malignant disease of the distal bile duct. In: Moody FG (ed) Advances in diagnosis and surgical treatment of biliary tract disease. Masson, New York, p 114, with permission)

Another stab wound is made in the jejunal loop 3 or 4 cm distally, and the bile duct anastomosis is accomplished using permanent interrupted sutures through all layers. This anastomosis is stented with a T tube, the external limb of which is brought out proximal to the anastomosis. Approximately 25 to 30 cm distally, an end-to-side duodenojejunal anastomosis is made in two layers: an inner layer with a running suture of chromic catgut and an outer layer with permanent interrupted sutures.

Ordinarily, the anastomoses are made to an antecolic jejunal loop. At times, in obese individuals, it is necessary to bring the jejunal loop through a defect in the transverse mesocolon.

Four suction drains are placed posterior to the biliary and pancreatic anastomoses. The T tube and drains are brought out the upper end of the vertical incision, and the pancreatic tube is brought out through a stab wound in the right upper quadrant (Fig. 10).

Postoperative care is extremely important because the morbidity rate is high. Complications can occur from leakage at the biliary or pancreatic anastomosis, infection in the abdomen, or bleeding from erosion of vessels in the abdomen. Pulmonary complications, such as adult respiratory distress syndrome or infection in various lobes and segments of lung, can occur. The most common complication is delay in gastric emptying, which requires use of a nasogastric tube for more than 7 days. Nutritional support by hyperalimentation is important in these patients.

Drainage from the Jackson-Pratt drains is monitored. When a high concentration of amylase (thousands per ml) is found, it is desirable to irrigate the retroperitoneum with Ringer's lactate solution up to 1 l/d. Irrigation is performed by infusing the solution through one suction drain and removing the irrigant throught the others. This procedure helps prevent infection and erosion of vascular structures by toxic pancreatic juice. Suction on the pancreatic stent frequently withdraws 200 ml to 300 ml of pancreatic juice per day during the healing period. If leakage develops, less pancreatic juice bathes the retroperitoneum.

Administration of antibiotics is continued postoperatively for variable times and is stopped when the patient is afebrile with a pulse rate of less than 100 bpm. Major leakages from the pancreatic or biliary tract anastomosis

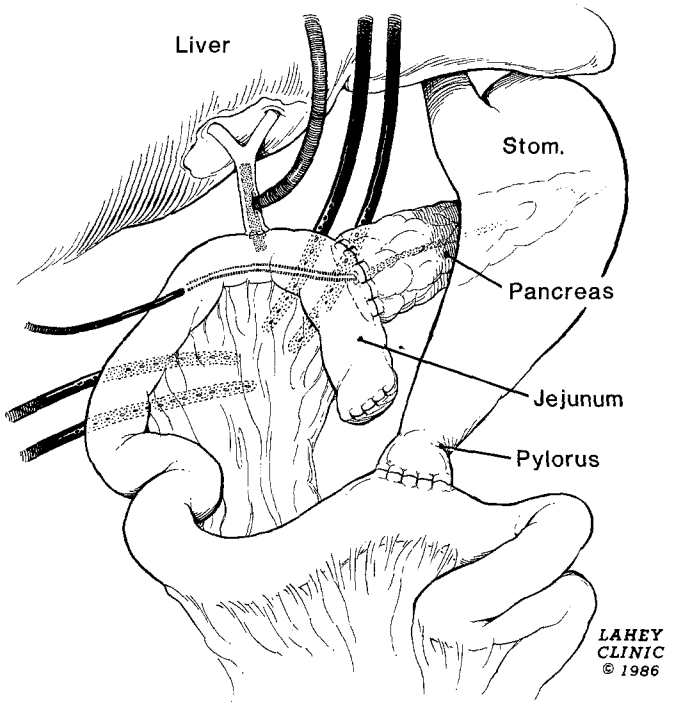

Fig. 10. Completed anastomoses with drains in place (by permission of Lahey Clinic)

require reoperation and resuturing or, more often, completion pancreatectomy for pancreatic dehiscence.

The use of gastrostomy instead of nasogastric tube suction is an option in view of the inordinately long time that nasogastric tubes must be in place in some patients.

Results

The postoperative mortality rate associated with pancreatoduodenectomy has been reduced in centers with adequate experience. In the past, a 20% mortality rate was common [7]; today, a mortality rate of more than 5% is unacceptable. In the past, the most common cause of death after operation was massive hemorrhage from infection and leakage at the pancreatic or biliary anastomosis, or both; now, the common problems are multisystem organ failure and respiratory failure [5, 37]. This improvement is a reflection of refinements in the technique of pancreatic anastomosis and the emphasis by surgeons on precise suturing of anastomoses and accurate dissection in the resection. In a recent review of our experience (Gagner M, Rossi RL, Braasch JW. Unpublished data, 1990), postoperative deaths occurred largely in patients 70 years of age and older and especially when these individuals had measurable abnormalities in cardiac, pulmonary, or renal function and a history of problems in these systems. Thus, our overall mortality rate associated with pancreatoduodenectomy in more than 170 patients is about 4%. However, patients more than 70 years of age with problems in their major organ systems have a mortality rate of more than 40% (unpublished data, 1990). Therefore, as surgeons extend the limits of the procedure to patients with more extensive tumors and especially to patients whose tumors were heretofore thought to be nonresectable because of associated risk factors, the mortality rate tends to rise.

Pylorus- and gastric-preserving pancreatoduodenectomy was designed to preserve an important part of the digestive process by retaining the mixing and digesting functions of the stomach, which are appreciably lost after gastric resection [62]. That these functions are not lost is suggested by the lack of postgastrectomy syndromes of dumping and afferent loop obstruction after this operation. Radioactive scan studies [5, 40] have shown that the stomach empties normally and that the pylorus functions at least partially to impede biliary reflux. Furthermore, a review [5] of the body weight of patients shows that 101% of preoperative and 95% of preillness weight is regained in the year after operation in patients in whom a recurrent malignant process was not present.

Technically, the pylorus-preserving operation is simpler and faster to perform than the operation requiring partial gastrectomy and possibly truncal vagotomy.

The incidence of jejunal ulceration after pancreatoduodenectomy has ranged from 6% to 20% [19], and preservation of the stomach might by thought to increase this prevalence. In our experience with 170 procedures, only three patients required another operative procedure for ulceration. In one of these patients no ulcer was found at surgical resection of the gastrojejunostomy and in one other patient who had transthoracic vagotomy, the ulcer was not visualized. Ten other patients had a provisional diagnosis of jejunal ulcer and were treated successfully without operation.

The world experience with the use of pylorus-preserving and nonpylorus-preserving pancreatoduodenectomy for chronic pancreatitis is shown in Table 1 [14–16, 23, 31, 37, 42, 43, 50]. Reasonable long-term follow-up review indicated that good to excellent results for relief of pain are expected at 5 years in about 80% of patients in our series and others [14–16, 23, 31, 37, 42, 43, 50]. Of great importance is the selection of the patient for resection and the selection "out" of patients who continue to drink, who are addicted to narcotics, who have diffuse pancreatic disease, or who are otherwise unlikely candidates for operation.

The price paid for removal of islet cells with any resective procedure is an increase in the diabetic rate. Pylorus-preserving pancreatectomy is no exception to this rule and carries with it a 45% and 69% insulin-dependent rate at 2 and 5 years [42] compared with a 40% to 56% insulin-dependent rate when resection is not performed [2]. However, this procedure is used in patients without ductal dilatation who, therefore, are not good candidates for pancreaticojejunostomy.

Berger et al. [3] reported a resective procedure for patients with chronic pancreatitis that involves removal of the neck and part of the head and uncinate process of the pancreas but preserves the duodenum, distal bile duct, and ampulla of Vater. It remains to be seen whether this procedure will produce equivalent results after 5 years of follow-up study.

The results of pylorus-preserving or standard pancreatoduodenectomy for the treatment of patients with ade-

Table 1. Results of pancreatoduodenectomy for chronic pancreatitis[a]

Author	Year reported	Total cases (no.)	Post-operative mortality (%)	Pain relief		Diabetic		Late mortality	
				Mean follow-up (years)	Good to excellent (%)	Preop-erative (%)	Postop-erative (%)	Follow-up (years)	(%)
Leger et al. [31]	1974	16	6.0	5+	75	–	–	–	–
Frey et al. [14]	1976	19	5.3	5± [b]	64	15	26	1–20	14.0
Sarles et al. [43]	1982	23	8.7	5	71	–	–	–	50.0
Gall et al. [15]	1982	116	0.9	1	93	54	56	–	3.5
Moreaux [37]	1984	50	2.0	10.7	73	–	–	5–18	50.0
Rossi et al. [42]	1987	73	2.7	4.9 [b]	79	25	64	1–20	26.0
Stone et al. [50]	1988	15	0	6.2	80	–	–	6	20.0
Gall et al. [16][c]	1989	289	1	8	88	17	53	8	19.0
Howard et al. [23]	1990	16	0	5+	94	–	–	10	0

[a] Adapted from Braasch JW (1988) Pancreaticoduodenal resection. Curr Probl Surg 25:358, with permission
[b] Range 1 to 20
[c] Occlusion of pancreatic duct with ethibloc

Table 2. Results of pancreatoduodenectomy for adenocarcinoma[a]

Author	Year reported	Primary site	Cases (no.)	Postoperative mortality (%)	Follow-up (years)	Alive without disease (%)
Warren et al. [58]	1975	Pancreas	150	10	5	13
Nakase et al. [38]	1977	Pancreas	308	25	5	3
Edis et al. [12]	1980	Pancreas	162	16	5	8
Herter et al. [21]	1982	Pancreas	75	18	5	5
Trede [54]	1985	Pancreas	41	0	5	28
Grace et al. [18]	1986	Pancreas	37	–	4.5	13 [b]
Tsuchiya et al. [57]	1986	Pancreas [c]	75	4	5	30 [d]
Martin et al. [33]	1990	Pancreas	22	–	3–5	13 [b]
Warren et al. [58]	1975	Ampulla	112	8	5	32
Nakase et al. [38]	1975	Ampulla	330	16	5	6
Akwari et al. [1]	1977	Ampulla	87	13	5	34
Lerut et al. [32]	1984	Ampulla	24	12	5	50
Tarazi et al. [52]	1986	Ampulla	46	13 [e]	5	38
Neoptolemos et al. [35]	1987	Ampulla	24	12.5	5	56 [b]
Martin et al. [33]	1990	Ampulla	23	–	3–5	43 [b]
Warren et al. [58]	1975	Distal bile duct	47	17	5	25
Nakase et al. [38]	1977	Distal bile duct	157	22	5	6
Martin et al. [33]	1990	Distal bile duct	18	–	3–5	39 [b]
Warren et al. [58]	1975	Duodenum	39	11	5	41
Joesting et al. [28]	1981	Duodenum	39	25	5	29

[a] Adapted from Braasch JW (1988) Pancreaticoduodenal resection. Curr Probl Surg 25:359, with permission
[b] Actuarial analysis
[c] Tumors 2 cm or less
[d] 37% for stage 2
[e] Significantly lower mortality last decade

nocarcinoma of the pancreas and periampullary region are shown in Table 2. Our results [33] are equal to if not superior to the results of others [1, 12, 18, 21, 28, 32, 38, 39, 52, 54, 57, 58] performing standard pancreatoduodenectomy. Once again, the selection of the patient has a bearing on the result. When tumor does not extend to the hepatic artery, superior mesenteric artery, or into portal or superior mesenteric veins, the result can be expected to be better. The size of the lesion does not seem to matter [33]. At present, our [33] current 5-year survival, as determined by the Kaplan-Meier product limit method, is 13% for patients with carcinoma of the pancreas, 43% for patients with carcinoma of the ampulla, 39% for patients with carcinoma of the distal bile duct, and approximately 53% for patients with carcinoma of the duodenum.

As has been point out by some authors [34, 47], preservation of the distal stomach, pylorus, and first portion of the duodenum risks leaving cancer cells behind. With the pylorus-preserving procedure, the structures, which are preserved, carry with them little fat and lymphatic tissue. Then, too, when this tissue is involved by tumor, it is extremely unlikely that operative resection that includes this tissue will result in cure.

Lesser resections of only the ampulla of Vater for ampullary carcinoma are likely to be followed by local recurrences of the tumor [46]. This fact precludes serious consideration of this procedure for any patient except patients in whom a diagnostic biopsy is needed.

Questions arise as to the usefulness of a wider more radical resection than is usually performed with standard pancreatoduodenectomy. In particular, should the portal and superior mesenteric vein segments be removed and should lymph node dissection along the aorta include the celiac axis or should segments of arteries and other vascular structures be removed in addition [13, 26, 48]? We maintain a healthy skepticism that wide excision of vascular structures along with nodes will improve the dismal results for patients with carcinoma of the pancreas. We watch with interest the results from some surgical centers [26] that perform routine lymph node dissection. We recognize that portal vein and superior mesenteric vein segments can be excised when they are invaded directly by tumor, but in the end, we wonder whether many lives will be saved when these vein segments are included in the resection.

Conclusions

Our experience with 170 patients with pylorus- and gastric-preserving pancreatoduodenectomy leads us to believe that the technical aspects, operative mortality, and short- and long-term results indicate that this procedure is the procedure of choice for patients with ampullary and periampullary neoplasms and for certain patients with pancreatitis.

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