PAPER

Transgastric Pancreaticogastric Anastomosis

An Alternative Operative Approach for Middle Pancreatectomy

Jennifer LaFemina, MD; Parsia A. Vagefi, MD; Andrew L. Warshaw, MD; Carlos Fernández-del Castillo, MD

Objective: To determine short-term outcomes following middle pancreatectomy with transgastric pancreaticogastric anastomosis.

Design, Setting, and Patients: A retrospective analysis of 23 patients who underwent middle pancreatectomy with transgastric pancreaticogastric anastomosis at the Massachusetts General Hospital, Boston, from June 22, 2005, through April 29, 2009.

Main Outcome Measures: Indications for procedure, operative time, length of stay, morbidity, mortality, and need for readmission, antibiotics, reoperation, additional procedures, or transfusion.

Results: The mean age of 15 women and 8 men who underwent middle pancreatectomy with transgastric pancreaticogastric anastomosis was 55.0 years. The median follow-up time was 12.9 months. The most commonly resected tumors were intraductal papillary mucinous neoplasms (n=9), serous cystadenomas (n=5), and neuroendocrine tumors (n=4). The mean (SD) operative time was 191 (39) minutes. No patients required intraoperative transfusion. The median hospital stay was 5 days. The most common complications were pancreatic fistula (n=6), intra-abdominal abscess (n=4), and superficial skin infection (n=4). Three patients had splenic artery pseudoaneurysms. Seven patients required readmission; 2 required reoperation. No patients developed postoperative new or worsening endocrine or exocrine insufficiency. There were no deaths.

Conclusions: Middle pancreatectomy with transgastric pancreaticogastric anastomosis offers a safe alternative to the traditional Roux-en-y pancreaticojejunostomy and may be technically simpler.

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LESIONS OF THE PANCREATIC neck and proximal body pose a challenge to surgeons. Middle pancreatectomy (MP) has provided an alternative to pancreaticoduodenectomy or extended distal pancreatectomy for benign or borderline lesions in this location.[1] Unlike the more extensive resections, MP allows for preservation of functional tissue, thereby reducing the risk of postoperative endocrine and exocrine insufficiency.[2-9] It is also an alternative for enucleation of small lesions in the neck of the pancreas, where the pancreatic parenchyma is often thin and removal can compromise the main pancreatic duct. In addition, splenic preservation is a major benefit of MP particularly in younger patients. Removal of the spleen can compromise the immunological state as has been demonstrated in patients undergoing distal pancreatectomy.[10] For those who have had distal pancreatectomy with splenectomy, the risk of perioperative morbidity, length of stay (LOS), and infections were significantly greater than in those in whom splenectomy was not performed.[10]

Most series show that postoperative pancreatic fistula (POPF) rates after pancreaticoduodenectomy are at least 10%, and half of the mortality after the Whipple procedure is related to POPF.[11-13] A number of variations to the traditional pancreaticojejunostomy (PJ) anastomosis have been proposed to address pancreatic anastomotic leaks and the morbidity and mortality that result, but no variation in operative technique has definitively reduced the incidence of POPF. In this light, attention shifted to pancreaticogastric (PG) anastomosis, a technique first described in humans by Waugh and Clagett.[14] Initial benefits included its ease of creation, absence of anastomotic tension given the pancreas' natural apposition to the posterior wall of the stomach, and a theoretical reduction in the risk of pancreatitis and POPF given the neutralization of pancreatic trypsin by gastric acid. Since that time,

Author Affiliations:
Department of Surgery, Massachusetts General Hospital and Harvard Medical School, Boston.

a number of groups have evaluated the incidence of POPF with PG anastomosis. Several studies suggested that, compared with PJ anastomosis, PG anastomosis may reduce the rate of POPF,[11,15,16] although a prospective, randomized controlled trial of 145 patients undergoing PG or PJ anastomosis during pancreaticoduodenectomy did not show any difference in the incidence of POPF between the groups.[17] Bassi et al[18] described 50 consecutive patients undergoing transgastric PG (TPG) anastomosis after pylorus-preserving pancreaticoduodenectomy. Patients were selected if their pancreata were soft or at high risk for POPF. The rates of complication (30%) and POPF (8%) were lower than previously reported in their other series, and all of the POPFs resolved with nonoperative management. Although it was not a randomized controlled trial, this pilot study suggested that TPG anastomosis could be used as an alternative to previously described pancreatic anastomoses without adding undue risks.

Looking at the role of PG anastomosis specifically with MP, Sauvanet et al[19] reported on MP reconstructed with a PJ (n=26) or PG (n=25) anastomosis. Although the 2 cohorts had preservation of long-term endocrine function, they both had a higher risk of POPF (28% for the PG anastomosis group and 31% for the PJ anastomosis group) compared with estimates after pancreaticoduodenectomy. While 2 other reports on 44 patients[9] and 12 patients[20] undergoing MP with PG anastomosis have reported POPF rates less than 10%, Efron et al[21] confirmed the earlier findings by Sauvanet and colleagues demonstrating a 36% incidence of POPF in a cohort of 14 patients. Although the risk of leak after MP does not seem to be purely additive, MP with its 2 sources of leak theoretically has an increased risk of POPF relative to pancreaticoduodenectomy or distal pancreatectomy.

Here we describe our institution's experience with MP with TPG anastomosis.

METHODS

STUDY DESIGN AND OBJECTIVES

The study consisted of a retrospective analysis of all patients who underwent MP with TPG anastomosis at the Massachusetts General Hospital, Boston, from June 22, 2005, through April 29, 2009. Patients were selected for MP with TPG anastomosis if they were believed to have nonmalignant tumors of the pancreatic neck or body that could not be safely enucleated without compromise to the main pancreatic duct or that, with a more extensive resection, would cause undue loss of normal pancreatic tissue (**Figure 1**). The objective of the study was to determine main outcome measures after MP with TPG anastomosis, including the following: operative time, LOS, morbidity, mortality, and need for readmission, antibiotics, reoperation, additional procedures, or transfusion. The study was conducted in compliance with the institutional human research committee procedures.

INCLUSION AND EXCLUSION CRITERIA

Patients were eligible for inclusion if they underwent MP with TPG anastomosis at the Massachusetts General Hospital from June 22, 2005, through April 29, 2009. No patients were excluded from the analysis.

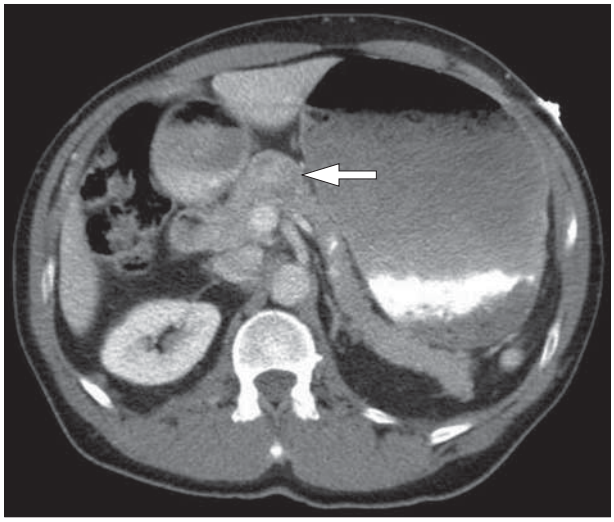

Figure 1. Imaging of a serous cystadenoma of the pancreatic neck. A 58-year-old man presented with epigastric pain, nausea, and vomiting. Computed tomography of the abdomen and pelvis revealed a 2.5 × 2.7-cm, well-circumscribed, heterogeneous mass at the pancreatic neck (arrow). Although preoperative imaging suggested that the lesion might be a neuroendocrine tumor, final pathology confirmed serous cystadenoma.

DATA COLLECTION

Electronic medical records were evaluated for patient age, sex, comorbid conditions (including cardiac or pulmonary disease as well as diabetes), presence of symptoms, tumor location and pathologic findings, operative time, LOS, tumor recurrence, morbidity (including postoperative pancreatitis, new or worsening diabetes, new-onset exocrine insufficiency, and POPF), need for readmission, interventional radiological (IR) drainage, antibiotics, total parenteral nutrition, packed red blood cells during initial admission, reoperation, and mortality. The POPFs were further assessed for duration and classification as per previously established guidelines.[22] Electronic medical records were evaluated for follow-up data for all patients from June 22, 2005, through June 28, 2009. Follow-up data (including outpatient and inpatient encounters) related to the initial operation were collected for morbidity, mortality, need for readmission, and need for further procedures.

OPERATIVE TECHNIQUE

Through an upper midline incision, the abdomen is inspected for evidence of metastatic disease. The porta hepatis is dissected, and a plane is developed behind the neck of the pancreas. The gastrocolic omentum is opened, and the lesser sac is developed. The superior mesenteric vein is then identified and dissected free along its anterior surface (**Figure 2**). A Penrose drain is passed through the retropancreatic space above the portal vein and superior mesenteric vein (**Figure 3**). Stay sutures are placed above and below the neck of the pancreas. The proximal pancreatic transection is performed with a gastrointestinal anastomosis stapler (generally a 60-mm stapler with 4.8-mm staples) with Seamguard (Gore, Newark, Delaware) (**Figure 4**). The proximal body of the pancreas is then mobilized off the splenic vessels until the area beyond the tumor has been reached. Splenic vein branches to the pancreas are meticulously ligated. The distal line of transection beyond the tumor is divided with electrocautery, and the specimen is re-

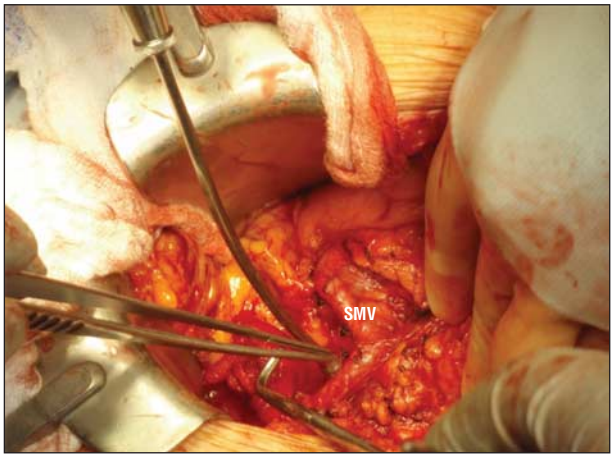

Figure 2. Identification of the superior mesenteric vein (SMV). The porta hepatis is dissected, and a plane is developed behind the neck of the pancreas.

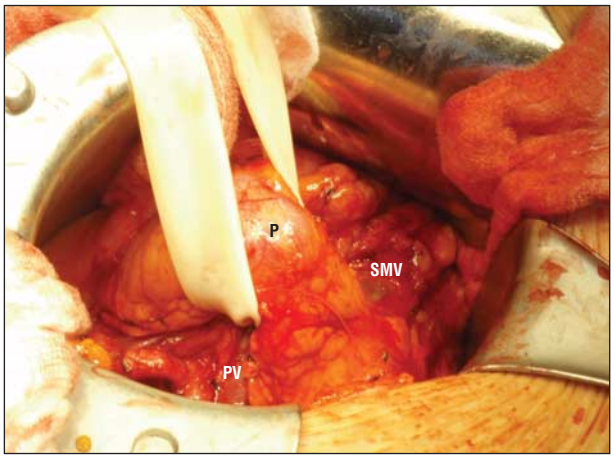

Figure 3. Development of the retropancreatic plane. After the gastrocolic omentum is opened, the lesser sac is entered. A Penrose drain is placed in the retropancreatic space above the portal vein (PV) and superior mesenteric vein (SMV). P indicates pancreas.

moved. The pancreas is further mobilized from the splenic vessels for a distance of 2.5 cm to facilitate anterior rotation of the pancreatic stump toward the posterior gastric wall for creation of the PG anastomosis. An anterior gastrotomy is made, which is followed by a posterior gastrotomy. The pancreas is delivered through the posterior gastrotomy. A TPG anastomosis is created using full-thickness bites of the stomach to the pancreas with a single layer of 3-0 silk sutures. A 5F feeding tube is placed in the pancreatic duct to prevent injury to this structure. The feeding tube remains in place until postoperative day 21, at which time it is removed in the office. The anterior gastrotomy is closed with running 2-0 chromic sutures, followed by interrupted 3-0 silk sutures (**Figure 5**). A Jackson-Pratt drain is placed adjacent to the anastomosis and pancreatic stump. The abdomen is closed in a standard fashion.

RESULTS

DEMOGRAPHIC AND CLINICAL CHARACTERISTICS

Twenty-three patients who underwent MP with TPG anastomosis from June 22, 2005, through April 29, 2009, were identified and analyzed in this study. The median length of follow-up was 12.9 months (range, 2.0-48.2 months).

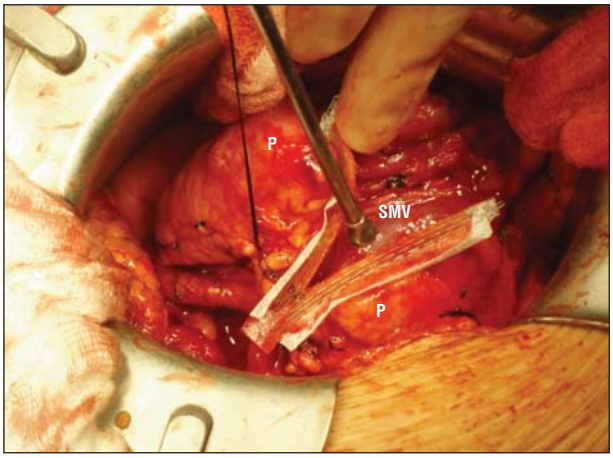

Figure 4. Proximal pancreatic transection. Stay sutures are placed above and below the neck of the pancreas (P). Proximal pancreatic transection is performed with a gastrointestinal anastomosis stapler with Seamguard (Gore, Newark, Delaware). The proximal pancreatic body is then separated from the splenic vessels. Splenic vein branches to the pancreas are ligated. The distal aspect of the resected pancreas is transected with cautery (not shown). SMV indicates superior mesenteric vein.

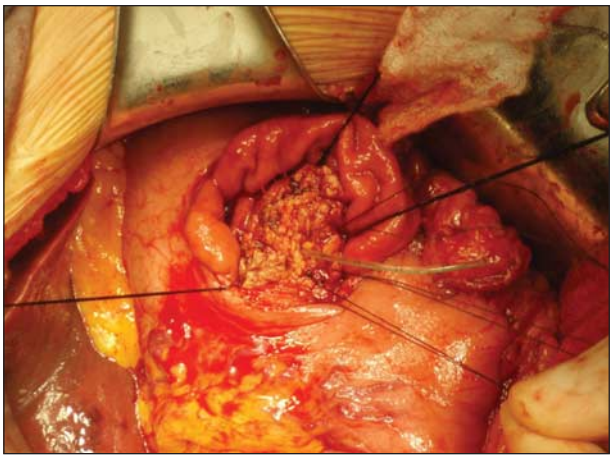

Figure 5. Transgastric pancreaticogastric anastomosis. An anterior gastrotomy is made, followed by a posterior gastrotomy. The pancreas is delivered through the posterior gastrotomy. The pancreaticogastric anastomosis is made using full-thickness bites of the stomach to the pancreas with a single layer of 3-0 silk sutures. A 5F feeding tube may be used in the pancreatic duct to prevent injury. The anterior gastrotomy is closed with running 2-0 chromic sutures, followed by interrupted 3-0 silk sutures.

Clinical characteristics are summarized in **Table 1**. The mean age of the 23 patients was 55.0 years (range, 15-82 years). Women composed 65% (n=15) of the study group. No patients had comorbid cardiac or pulmonary conditions. Three patients had preoperative diabetes mellitus, and 1 of them required insulin preoperatively.

Eleven patients (48%) were asymptomatic at the time of presentation, and the remaining 12 patients reported pain (n=10), hypoglycemia (n=1), or other symptoms (n=1).

OPERATIVE DETAILS

All patients underwent MP with TPG anastomosis. No patients had a concurrent splenectomy. The mean (SD)

Table 1. Characteristics and Histopathologic Diagnoses of Patients in Middle Pancreatectomy With Transgastric Pancreaticogastric Anastomosis Cohort

Characteristic	Value
Patients, No.	23
Women, No. (%)	15 (65)
Symptomatic, No. (%)	12 (52)
Age, mean (SD), y	55.0 (15.2)
Follow-up, median (range), mo	12.9 (2.0-48.2)
Diagnosis, No. (%)	
IPMN	9 (39)
Serous cystadenoma	5 (22)
Neuroendocrine tumor	4 (17)
MCN	1 (4)
IPMN + neuroendocrine tumor	1 (4)
Solid pseudopapillary tumor	1 (4)
Solid serous adenoma	1 (4)
Indeterminate mucinous lesion	1 (4)

Abbreviations: IPMN, intraductal papillary mucinous neoplasm; MCN, mucinous cystic neoplasm.

Table 2. Complications After Middle Pancreatectomy With Transgastric Pancreaticogastric Anastomosis

Complication	No. (%)
Postoperative pancreatic fistula	6 (26)
Intra-abdominal abscess	4 (17)
Superficial skin infection	4 (17)
Splenic artery pseudoaneurysm	3 (13)
Fluid collection, spontaneous resolution	1 (4)
Anastomotic stricture	1 (4)
Acute pancreatitis	1 (4)
Incisional hernia	1 (4)
Deep venous thrombosis	1 (4)
Mallory-Weiss tear	1 (4)
New-onset endocrine insufficiency	0
New-onset exocrine insufficiency	0
Need for readmission	7 (30)
Need for reoperation	2 (9)
Death	0

operative time was 191 (39) minutes. No packed red blood cell transfusions were required intraoperatively or during the index admission. Eleven tumors (48%) were located in the pancreatic neck, 9 (39%) were in the body, 2 (9%) were in the neck or proximal body region, and 1 (4%) was in an unspecified location.

SURGICAL PATHOLOGIC FINDINGS

Table 1 summarizes the final histopathologic diagnoses. Intraductal papillary mucinous neoplasms were the most common lesion leading to MP with TPG anastomosis (n=9 [39%]). Serous cystadenomas and neuroendocrine tumors contributed 22% (n=5) and 17% (n=4), respectively. Mucinous cystic neoplasm, a solid pseudopapillary tumor, solid serous adenoma, a synchronous intraductal papillary mucinous neoplasm with a neuroendocrine tumor, and an indeterminate mucinous lesion were resected in 1 case (4%) each.

LOS AND READMISSION AFTER MP WITH TPG ANASTOMOSIS

The median postoperative LOS after surgery was 5 days. Of the 23 patients, 7 (30%) required readmission during follow-up. Indications for readmission included intra-abdominal abscess (n=3), hemorrhage due to splenic artery pseudoaneurysm (n=3), and postoperative pancreatitis (n=1).

MORBIDITY AND MORTALITY AFTER MP WITH TPG ANASTOMOSIS

Sixteen of 23 patients (70%) sustained at least 1 surgical or medical complication (n=23 total complications; **Table 2**). The most common complication was POPF (n=6 [26% of total complications]). However, the POPFs were generally of little clinical significance and resolved spontaneously. Five were grade A, and 1 was complicated by an intra-abdominal abscess and thus was grade B. The median time to fistula closure was 18 days (mean, 19 days), and all were managed nonoperatively in the outpatient setting. Additional complications included intra-abdominal abscess (n=4 [17%]), superficial skin infection (n=4 [17%]), hemorrhage due to splenic artery pseudoaneurysm (n=3 [13%]), and 1 (4%) each of fluid collection with spontaneous resolution, anastomotic stricture, acute pancreatitis, incisional hernia, deep venous thrombosis, and Mallory-Weiss tear. Seven patients (30%) had no complications.

Five patients (22%) required a postoperative IR procedure in follow-up for either intra-abdominal abscess or splenic artery pseudoaneurysm. Nine patients (39%) required postoperative antibiotics. Three patients (13%) required total parenteral nutrition, and 2 patients (9%) required an additional operation (1 for hemorrhage due to splenic artery pseudoaneurysm and 1 due to incisional hernia that was detected 10 months after the MP).

Postoperative splenic artery pseudoaneurysm with hemorrhage affected 3 patients (13%) who had TPG anastomosis. The median time from operation to readmission for pseudoaneurysm was 14 days. The most common presenting symptoms were hematemesis (n=3), abdominal pain (n=2), and melena (n=1). Two patients underwent IR-guided coil embolization; 1 patient was taken to the operating room, at which time the patient had an exploratory laparotomy, distal pancreatectomy, splenectomy, and splenic artery ligation. The median LOS was 18 days, and there were no deaths.

There were no new cases of postoperative endocrine insufficiency. In 1 of the 3 patients with preoperative diabetes, glucose control was improved postoperatively. There were no cases of exocrine insufficiency after MP with TPG anastomosis.

There were no operative deaths either during the index admission or during follow-up in the TPG anastomosis group.

COMMENT

With the advent of more frequent abdominal imaging and the consequent increase in incidentally discovered pancreatic lesions,[23] segmental resections for benign and bor-

derline lesions of the pancreatic neck and proximal body will be increasingly useful operative techniques. Unlike the more standard pancreaticoduodenectomies or extended distal pancreatectomies, MP offers the benefit of preserving uninvolved, functional pancreatic tissue for these nonmalignant tumors of the pancreatic neck and proximal body. The risk of postoperative endocrine and exocrine insufficiency, which has been well documented after the standard operations,[1,24-30] is thereby minimized in patients undergoing MP. The estimated risk of postoperative endocrine insufficiency after MP is approximately 4%, which is significantly less than the 10% to 40% risk estimated in all standard resections.[1,20,24,27,28,30-32] Similarly, the cumulative published risk of postoperative exocrine insufficiency following MP is approximately 3% to 5%,[1,4] which again is significantly less than the estimated 25% to 50% following standard pancreaticoduodenectomy.[20,24,31,32] In this study, no patients developed new-onset or worsening endocrine or exocrine insufficiency. In comparison with our previous larger combined experience, it is likely that as we expand our use of MP with TPG anastomosis, we will see incidences that approach those reported by Crippa et al.[1]

In this study, we report that 16 patients (70%) sustained 1 or more complication. Unlike most prior studies reporting a 10% to 63% complication risk after MP (most commonly after PJ anastomosis), our study reports the cumulative risk of all (medical and surgical) complications rather than just surgical complications (ie, fistulas, abscess, hemorrhage). In fact, in the few studies that report both medical and surgical complications, the risk of each group is sometimes as high as 25% to 30%, allowing for a cumulative risk similar to that found in our study.[9,33]

In 1988, Warshaw[34] described a technique for splenic preservation in the setting of distal pancreatectomy. The Memorial Sloan-Kettering Cancer Center team evaluated the outcomes of patients undergoing distal pancreatectomy, with and without splenectomy, for benign or low-grade malignant lesions. Similar to prior reports on gastric cancer, they found that splenic preservation was associated with a significant reduction in perioperative infections, severe complications, and LOS.[10,35] In our study, 4 patients (17%) developed a postoperative intra-abdominal abscess. Three required IR-guided drainage and antibiotics; the remaining subject had a previously placed operative drain in a position adequate for drainage. Crippa et al[1] reported an intra-abdominal collection incidence of 9% in patients undergoing MP without POPF; the risk increased to 41% in those with a grade B or C POPF. Ferrone et al[23] reported a 4% risk of intra-abdominal infection with an 18% risk of POPF; however, the data set represents patients undergoing resection of cystic lesions regardless of the resection type. Our incidence of 17% for intra-abdominal abscess is similar to prior reports and is likely to some extent based on our POPF incidence (26%), the latter of which is increased in MP vs other standard resections.[23] As we do not have a splenectomy control group, we cannot draw conclusions on the specific benefit of splenic preservation relative to infection risk. Ultimately, all intra-abdominal abscesses resolved with drainage and antibiotics and did not result in any mortality.

From a purely technical perspective, TPG anastomoses are less complex, require a shorter operative time (in this study, a mean [SD] operative time of 191 [39] minutes), obviate the need for a small-bowel resection, and eliminate the need for an enteric anastomosis. With these advantages, we have moved toward using TPG anastomosis in place of PJ anastomosis during MP. In this study, the risk of POPF was about 26%; however, the risk of clinically significant fistulas (grade B or C) was less frequent (4% incidence of grade B, 0% incidence of grade C). In contrast to reports of MP being associated with a POPF rate in excess of 30%,[4,7,19,21,36] our data demonstrate a lower POPF rate of 26% and an acceptable, low risk of clinically significant leaks as all POPFs resolved with drainage alone. While no POPF resulted in death, the 1 reoperation for hemorrhage related to pseudoaneurysm was likely a consequence of POPF. Although attempts have been made to standardize the definition of POPF, it is not uncommon that postoperative abscesses, pseudoaneurysms, and hemorrhages—which at times are likely complications of POPF—are not included in reported POPF rates. This discrepancy can lead to falsely low reported POPF rates. It is possible that our own study may suffer from the same bias, as POPFs were defined as previously reported.[37] If we classify all postoperative fistulas, abscesses, pseudoaneurysms, and hemorrhages (n = 11 patients) as POPFs, then 48% rather than 26% of patients would have a POPF of some degree. If all groups adopted a more standardized, comprehensive definition of POPF, we would likely see a dramatic increase in the reported POPF rates.

Although the risks of POPF and endocrine and exocrine dysfunction are low, the risk of hemorrhage related to splenic artery pseudoaneurysm deserves special note. Three patients (13%) developed splenic pseudoaneurysms resulting in hemorrhage. Two patients were treated with IR-guided angioembolism, 1 required reoperation, and none died as a result of their hemorrhage. Given the overall infrequency of MP, there is still incomplete data regarding the risk of postoperative hemorrhage related to this procedure. It is possible that further mobilization of the pancreas after the specimen is removed—which implies dissection of the splenic artery and tying of small branches from the artery to the pancreas and which is done to facilitate the anastomosis—could predispose to this. Veillette et al[37] evaluated the experience of POPF after pancreaticoduodenectomy with PJ anastomosis at the Massachusetts General Hospital and found that we had an acceptably low incidence of POPF (12.9%). However, 12% of these (1.5% of the cohort) developed postoperative hemorrhage, most commonly from a pseudoaneurysm. Hemorrhage was associated with a nearly 67% risk of mortality. Owing to the limited sample size in the MP with TPG anastomosis cohort and as the data regarding PJ anastomosis must be extrapolated from the pancreaticoduodenectomy cohort, it is not clear at this time whether MP with TPG anastomosis causes a significant increase in the risk of postoperative pseudoaneurysm and hemorrhage compared with PJ anastomosis. Our experiences with pancreaticoduodenectomies and with MP with TPG anastomosis highlight an important reminder that early recognition and prompt manage-

ment of presumed pseudoaneurysms will allow for minimization of morbidity and mortality following pancreatic resections.

In conclusion, MP with TPG anastomosis provides an alternative anastomotic approach to the standard PJ anastomosis during MP. As our data demonstrate, this operative technique not only results in the expected benefits of a segmental resection in terms of preservation of exocrine and endocrine function but also allows for a technically simpler reconstruction without undue risks of complications, including POPF.

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Correspondence: Carlos Fernández-del Castillo, MD, Department of Surgery, Massachusetts General Hospital, 15 Parkman St, WAC 4-460, Boston, MA 02114 (cfernandez@partners.org).
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