Outcomes of Endoscopic and Percutaneous Drainage of Pancreatic Fluid Collections Arising after Pancreatic Tail Resection

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BACKGROUND: Up to 15% to 30% of patients develop pancreatic fluid collections (PFCs) after pancreatic tail resection. Percutaneous and endoscopic methods have been used to drain these collections, though few data are available that compare outcomes of these modalities.

STUDY DESIGN: From December 1998 to April 2011, we identified all patients who underwent pancreatic tail resection and developed PFCs requiring intervention. The primary aim was to compare overall success rates in resolution of PFCs using endoscopic and percutaneous modalities. Success rates, hospital length of stay, number of CT scans, sinograms and endoscopies performed, and days with drain(s) in place were compared.

RESULTS: Forty-eight patients were identified. Percutaneous drainage was performed a median of 25 days postoperatively, compared with 85 days for endoscopic drainage (p = 0.001). Endoscopic and percutaneous methods had similar rates of technical success (100% vs 97%, p = 0.50) and treatment success (80% vs 81%, p = 0.92), respectively. Recurrence rates were 16.6% for the endoscopic group and 23% for the percutaneous group (p = 0.65), and adverse events occurred in 9.4% of those treated endoscopically vs 13.3% of those treated percutaneously (p = 0.68). Location and characteristics of PFCs did not influence success rates. Recurrences were often treated by “salvage” drainage via the other modality. Median hospital stay was longer after primary percutaneous drainage compared with primary endoscopic drainage (5.5 days vs 2 days, p = 0.046). Primary percutaneous drainage patients also had more CT scans (median 3 vs 2, p = 0.03).

CONCLUSIONS: Endoscopic drainage and percutaneous drainage appear to be equally effective and complementary interventions for PFCs occurring after pancreatic tail resection. Primary endoscopic drainage may be associated with shorter hospital stay and fewer CT scans. (J Am Coll Surg 2012;215: 177–185. © 2012 by the American College of Surgeons)
acceptable recurrence rates, but its use for collections arising after pancreatic tail resection is uncommonly reported. However, one study in which transmural endoscopic drainage was compared with percutaneous drainage of pancreatic pseudocysts that arose as a result of pancreatic resections or pancreatitis showed statistically similar success rates (21 of 25 [84%] vs 22 of 30 [73%], respectively, p = 0.532) and complication rates (2 of 25 [8%] vs 7 of 30 [23%], p = 0.159), though with a difference in recurrence rates (0 of 21 vs 6 of 22, p = 0.021).

In this study, we identified a cohort of patients who underwent pancreatic tail resection with subsequent PFC formation requiring treatment at our institution. Our aim was to compare percutaneous drainage to endoscopic drainage of PFCs that arise after pancreatic tail resection.

METHODS
We retrospectively identified all patients at Mayo Clinic, Rochester, MN, who underwent pancreatic tail resection between December 1998 and April 2011, using an institutional surgical procedures database used for coding and billing purposes. By keyword searching and individual review of electronic charts, we then identified those who required postoperative drainage of PFCs either endoscopically or percutaneously. Endoscopic drainage was also confirmed using an electronic endoscopy database that was cross-referenced to find postpancreatectomy fluid collections. Outcomes of these patients were determined by retrospective review of clinical and hospital notes and records. Selected CT scans were reviewed by an interventional radiologist who characterized PFC location as gastrosplenic, pararenal, paracolic, and/or retrogastric, and PFC characteristics as round or oval, bilobed, irregular, and/or multilocular or unilocular.

All patients had clinically relevant PFCs manifested by 1 or more of the following: abdominal pain, nausea or vomiting, fever, or leukocytosis. PFCs were diagnosed by either contrast-enhanced CT scan or transabdominal ultrasound. The maximal diameter of the PFC obtained by imaging before drainage was used to determine size.

CT-guided drain placement or aspiration was performed as previously described. One locking loop catheter, 8 to 10 F in diameter, was placed using the Seldinger technique. In most cases fluid was sent for Gram stain and culture. The catheter was irrigated with 10 mL of sterile saline 2 to 3 times daily and a sinogram was performed the next day to ensure proper placement and determine the need for repositioning or upsizing.

Transmural endoscopic drainage was performed as previously described with or without endoscopic ultrasound guidance. In most cases, fluid was aspirated and sent for Gram stain and culture. After entry, the transmural tract was balloon dilated using an 8- to 10-mm balloon. One to three 7- to 10-F double pigtail stents were then placed into the collection. On one occasion an 8 mm diameter × 4 cm fully covered expandable metal biliary stent (Viabil, Gore) was also placed. In a subset of patients whose PFC contained necrotic debris, either a nasobiliary tube was placed for irrigation purposes or an endoscope was passed into the cavity to debride it. Stents were removed 6 to 8 weeks later or when there had been clinical and radiographic resolution of the PFC.

In some patients, endoscopic transpapillary drainage was performed either as a primary drainage method or as an adjunct to endoscopic transmural drainage. In cases in which multiple endoscopic drainage routes were used, these were performed either simultaneously or in a staged fashion.

Technical success was defined as the ability to access and drain the PFC by endoscopic or percutaneous methods. Treatment success was defined as clinical and radiographic resolution of the collection with subsequent drain removal. Recurrence was defined as a collection reoccurring after removal of drains. Treatment failure was defined as continued symptomatic collection that required another intervention. Hospital days were calculated as the total number of inpatient days after initial intervention to the time of resolution, including rehospitalization for adverse events or symptoms. The terms percutaneous and endoscopic “salvage” are used to indicate the use of an endoscopic or percutaneous intervention after the alternate method had been previously used, though the 2 drain modalities may have been used in overlapping fashion. In 4 patients pancreatectomy had been performed at an outside institution and in 1 patient a percutaneous drain was already in place.

Statistical analysis was performed using chi-square testing for the primary endpoints, recurrence rate, and adverse event rate and Wilcoxon test was used to compare the secondary endpoints. Fisher’s exact test, Wilcoxon test, and chi-square testing were used to compare baseline demographics where noted.

RESULTS
From December 1998 to April 2011, 882 pancreatic tail resections were performed at our institution. Using our
search criteria, we identified 116 patients in our database who developed postoperative PFCs (13.2%). Only 48 of those patients, who developed a de novo PFC after pancreatic tail resection, underwent an endoscopic or percutaneous intervention. Table 1 divides the patients into those who underwent endoscopic \((n = 15)\) or percutaneous \((n = 33)\) drainage of their PFC as primary interventions. Because some patients were referred to our institution for treatment of a PFC, it was not always clear if the pancreatectomy was performed laparoscopically or open \((n = 3)\). Most patients (28 of 33) in the percutaneous group had PFCs that drainage less than 4 weeks postoperatively, compared with 8 of 15 in the endoscopic group \((p < 0.03\), median postoperative days 21 vs 85, \(p < 0.001\)). The indications for surgery were similar between the 2 groups, as were other demographics (Table 1). Patients were followed for a median of 329 days \((range 20 to 1,924 days)\) in the endoscopic group and 197 days \((range 17 to 3,077 days)\) in the percutaneous group from the time that all drains were removed. Abdominal CT data postdrain removal was available in 9 of the 15 primary endoscopic patients up to a median of 241 days \((range 46 to 1,507 days)\). Twenty-two of 33 primary percutaneous patients had Abdominal CT data up to a median of 409 follow-up days \((range 44 to 3,077 days)\). The anatomic location of the PFCs did not differ between the 2 groups,

<table>
<thead>
<tr>
<th>Patient characteristics</th>
<th>Primary percutaneous ((n = 33))</th>
<th>Primary endoscopic ((n = 15))</th>
<th>(p) Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex, male</td>
<td>14 (42.4%)</td>
<td>8 (53.3%)</td>
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<tr>
<td>Age, y, median (range)</td>
<td>53 (21–82)</td>
<td>53 (17–85)</td>
<td>1.00*</td>
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<td>Surgical approach</td>
<td></td>
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<tr>
<td>Laparoscopic</td>
<td>11 (33.3%)</td>
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<td>Open</td>
<td>22 (66.7%)</td>
<td>7 (46.7%)</td>
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<tr>
<td>Unknown</td>
<td>0 (0%)</td>
<td>3 (20%)</td>
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<tr>
<td>Surgical procedure</td>
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<tr>
<td>Distal pancreatectomy only</td>
<td>4 (12.1%)</td>
<td>3 (20%)</td>
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</tr>
<tr>
<td>Distal pancreatectomy with splenectomy</td>
<td>19 (57.6%)</td>
<td>8 (53.3%)</td>
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<td>Distal pancreatectomy with multiorgan resection</td>
<td>10 (30.3%)</td>
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<td>Indication</td>
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<td>Adenocarcinoma</td>
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<tr>
<td>Islet cell tumor</td>
<td>6 (18.2%)</td>
<td>4 (26.7%)</td>
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<td>Cystadenoma</td>
<td>9 (27.3%)</td>
<td>2 (13.3%)</td>
<td></td>
</tr>
<tr>
<td>Pseudocyst</td>
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<tr>
<td>Nesideoblastosis</td>
<td>3 (9.1%)</td>
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<tr>
<td>Intraductal papillary mucinous tumor</td>
<td>1 (3%)</td>
<td>1 (6.7%)</td>
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<tr>
<td>Solid pseudopapillary tumor</td>
<td>1 (3%)</td>
<td>1 (6.7%)</td>
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<td>Malignancy-other†,‡</td>
<td>4 (12.1%)</td>
<td>1 (6.7%)</td>
<td></td>
</tr>
<tr>
<td>Other§,¶</td>
<td>4 (12.1%)</td>
<td>2 (13.3%)</td>
<td></td>
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<tr>
<td>Maximum diameter of fluid collection, cm, median (range)</td>
<td>6.4 (2.8–16)</td>
<td>7 (4–19)</td>
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<td>Fluid location§</td>
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<td>Gastrosplenic</td>
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<td>5 (33.3%)</td>
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<tr>
<td>Pararenal</td>
<td>11 (33.3%)</td>
<td>4 (26.7%)</td>
<td></td>
</tr>
<tr>
<td>Paracolic</td>
<td>4 (12.1%)</td>
<td>1 (6.7%)</td>
<td></td>
</tr>
<tr>
<td>Retrogastric</td>
<td>22 (66.7%)</td>
<td>11 (73.4%)</td>
<td></td>
</tr>
<tr>
<td>Median time after operation, d (range)</td>
<td>21 (3–151)</td>
<td>85 (12–328)</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td>&lt;4 wk</td>
<td>28 (84.8%)</td>
<td>8 (53.3%)</td>
<td>0.03*</td>
</tr>
</tbody>
</table>

*Wilcoxon test.
†Endoscopic malignancy-other: metastatic renal cell carcinoma.
‡Percutaneous malignancy-other: adenosquamous carcinoma, gastrointestinal stromal tumor, neuroendocrine tumor, and retroperitoneal liposarcoma.
§Endoscopic other: disconnected duct syndrome, incidentally for pheochromocytoma, ectopic spleen.
¶Percutaneous other: pancreatic intraductal neoplasia, ectopic spleen, and splenic artery aneurysm.
Fluid collections may be in multiple locations in a patient.
Fisher’s exact test, all other \(p\) values were obtained by chi-square test.
nor was there a significant difference among treatment success, recurrence, or failure groups between and among the percutaneous and endoscopic groups (Table 1). PFCs were noted in multiple locations in 36.4% of patients in the percutaneous group and 40% of patients in the endoscopic group (p = 0.81) and no association with treatment success, recurrence, or failure were noted.

Figure 1 illustrates the flow of patients treated initially using endoscopic or percutaneous methods. Percutaneous drainage was used primarily at our institution for many years. Of the 21 endoscopic interventions, 15 were performed since 2008.

There were 2 technical failures in the percutaneous group. Initial CT-guided drainage was planned for a patient with a PFC measuring 9 cm × 5 cm, but there was no available window to allow drainage. Aspiration of 70 mL of fluid through a transpleural approach was performed, but a drain was not placed. The patient was readmitted 12 days later with worsening abdominal pain and the size of the collection was unchanged, but resolved after extended observation. The second technical failure occurred during attempted treatment of a recurrence. A collection initially resolved after a percutaneous drain was in place for 70 days. Seventeen days after drain removal the PFC recurred, was symptomatic, and measured 2.8 cm × 1.8 cm. Attempted CT-guided aspiration failed to access the collection. The patient was subsequently observed. All endoscopic interventions were technically successful (97% vs 100%, p = 0.50).

Of the technically successful drainages, as primary interventions the treatment success rates were 26 of 32 (81%) and 12 of 15 (80%) for percutaneous and endoscopic approaches, respectively (p = 0.99). Six of 26 (23%) recurrences were seen in the percutaneous group, of which 2 were initially percutaneous aspirations. Three patients underwent successful endoscopic “salvage” drainage. Two underwent successful repeat percutaneous drainage. The last recurrence is described in the previous paragraph and resolved without further intervention. Two of 12 (16.6%) recurrences were seen after the primary endoscopic intervention, with successful subsequent percutaneous “salvage” drainage (Fig. 2). The difference in recurrence rates was not statistically significant (p = 0.65).

Of the 6 of 32 percutaneous cases that were not treatment successes, 4 were failures and 2 had adverse events. Two failures were successfully treated using endoscopic “salvage” drainage performed 2 and 18 days after percutaneous drain placement respectively (Fig. 3). The other 2 patients with failures underwent successful repeat percutaneous catheter drainage. One of those failures had occurred because the percutaneous drain dislodged 7 days after placement. The other failure was after a CT-guided aspiration, where subsequent imaging 2 days later showed no significant change in the fluid collection size.

Three of the 15 primary endoscopic interventions were unsuccessful; 1 was a treatment failure and the other 2 had adverse events. The patient with treatment failure underwent a subsequent percutaneous “salvage” 6 days later. Only minimal improvement in the size of a 19-cm infected collection resulted (Fig. 4). The collection was managed surgically.
Three adverse events occurred after percutaneous intervention: 1 case of acute pancreatitis was believed to be secondary to instrumentation during CT-guided drain placement and manipulation but was ultimately successful in resolving the PFC, and there were 2 cases of major bleeding. The first hemorrhage occurred 2 days after CT-guided drain placement into a collection that developed 2 days after surgery. The patient underwent surgery and the drain was replaced, but no source of bleeding was found. The patient was subsequently found to have a gastroduodenal artery pseudoaneurysm, which was embolized. The other episode of bleeding occurred 6 days after a percutaneous intervention during a follow-up catheter exchange. Mesenteric angiography was performed and a bleeding vessel was embolized. Endoscopic salvage with a transpapillary drain was performed 3 days after the percutaneous intervention. Both the percutaneous catheter and endoscopic stents were in place until resolution of the PFC.

In the endoscopic group 2 adverse events occurred. One delayed bleeding occurred after successful transgastric cystgastrostomy and pigtail stent placement in a patient who required anticoagulation. Surgical oversewing of the entry point bleeding site was performed and a surgical drain was placed. The second adverse event consisted of transpapillary stent migration into the PFC that required retrieval by percutaneous methods followed by percutaneous drain...
placement. One patient had self-limited bleeding at the transgastric cystgastrostomy site that ceased with observation and no transfusion was required, but the patient was monitored overnight in the ICU.

Table 2 compares the outcomes measured and separates the groups into all primary interventions, successful primary interventions, and failed primary interventions. Simple aspirations were not included in Table 2. Notably, 50% (4 of 8) responded to aspiration alone in our cohort. There was a statistically significant longer median hospital stay associated with successful primary percutaneous drainage compared with successful primary endoscopic drainage. Three of the endoscopically treated patients were managed completely as outpatients compared with 2 percutaneous aspiration interventions. Simples aspirations were not included in Table 2. Notably, 50% (4 of 8) responded to aspiration alone in our cohort. There was a statistically significant longer median hospital stay associated with successful primary percutaneous drainage compared with successful primary endoscopic drainage. Among the primary percutaneous cases, an external drain remained in place a median of 29 days (interquartile range [IQR] 17 to 41 days) and 3 (IQR 2 to 5) sinograms were performed. In the 4 endoscopically treated patients who required percutaneous salvage interventions, a percutaneous drain was in place a median of 52 days (IQR 37.25 to 69.75 days, \( p = 0.048 \)) and required 3 (IQR 2.25 to 8.25) sinograms. When comparing the total number of days a percutaneous drain was in place with the total number of days an endoscopic drain was in place in the successful primary drainage group, the endoscopic drain was in place statistically longer than the percutaneous drain (44 days [IQR 37 to 47.75 days] vs 20 days [IQR 16.5 to 34 days], \( p = 0.004 \)).

Twenty-one endoscopic drainage interventions were performed in this cohort. Each intervention may have had 1 or multiple drainage methods as determined by endoscopist preference. There were 12 transpapillary, 13 transgastric, and 3 transduodenal approaches. Four were endoscopic ultrasound (EUS)-guided. A pancreatic fistula was identified in 11 patients either during a sinogram or ERCP. Five sphincterotomies were performed. Two patients had a previous sphincterotomy. In 2 of the successful cases, there was debridement of the PFC cavity by passage of the endoscope into the cavity to remove solid debris.

**DISCUSSION**

Surgically placed drains at the time of a pancreatic tail resection control ductal leaks, allow closure, and prevent development of pancreatic fluid collections. However, not all surgically placed drains communicate with the leak, or the drain may clog with debris, giving the false impression that the leak has sealed. Among our cohort of 116 postoperative PFCs, the 68 patients who did not undergo a percutaneous or endoscopic drainage intervention were treated using the surgically placed drain from their initial operation, with subsequent manipulation and/or catheter exchange.

A recent large study of 908 patients showed that 62% of complications after pancreatic tail resection presented after the initial discharge. In that study, 158 patients developed postoperative PFCs that were treated by percutaneous drainage alone in 133 and operation in 26. Patients required an average of 1.96 image-guided procedures and 2.76 CT scans during treatment of their PFCs. Percutaneous drains remained in place an average of 38 days and a 50% readmission rate was seen. So, the cost of managing postpancreatectomy PFCs is high.
To our knowledge, this is the first study that compares percutaneous and endoscopic drainage modalities for PFCs arising after pancreatic tail resection. As an initial treatment, both techniques have similar success rates, failure rates, and complication rates. Limitations of this study include its retrospective nature and small sample size. The endoscopic group tended to have PFCs that were identified much later after pancreatectomy, which likely indicates a slow persistent pancreatic ductal leak, but could change the nature of the collection and resultant outcome. In particular, the lower resource use we noted among the endoscopic group may have resulted from later presentation rather than the type of intervention. Our data show statistically longer days with a percutaneous drain among the percutaneous salvage patients in the primary endoscopic group compared with the primary percutaneous group, suggesting that these slow persistent leaks, seen predominantly in the endoscopic group, take longer to resolve. In our experience, waiting 4 to 6 weeks after first onset of a fluid collection before intervention, as suggested by older surgical literature, was to allow maturation so that the pseudocyst wall would hold sutures. When transmural endoscopic drainage is undertaken this delay does not appear to be necessary. Recommendations to wait 4 to 6 weeks before transmural drainage of PFCs after acute pancreatitis to prevent clogging of stents do not apply to this population.

Not surprisingly, ultrasound- or CT-guided aspiration alone as a treatment option for PFCs that arise after pancreatic resection was low, with a 50% (4 of 8) recurrence or failure rate in this study, and also is likely due to an ongoing ductal leak with reaccumulation of fluid. This has been demonstrated previously and some type of persistent drain is recommended for these collections.\textsuperscript{17}

In our cohort, endoscopic drainage was associated with shorter hospital stays and there were statistically fewer CT scans among the primary endoscopic group. This may imply a cost advantage to primary endoscopic drainage based on fewer hospital days, fewer CT scans, and no need for sinograms, but we did not perform a formal cost analysis. However, we believe the cost of initial drainage is similar between the 2 groups at our institution. Direct comparison is difficult because of the variability with each procedure (ie, inpatient vs outpatient, unique technical aspects of each procedure, cost shifting, etc).

Although the technical success of endoscopic interventions was 100% compared with 97% for percutaneous interventions, this is likely a result of available imaging before intervention, which introduces selection bias toward endoscopic drainage. We attempted to identify particular anatomic regions a PFC occupied that might be more amenable to drainage through percutaneous or endoscopic routes,
but we were not able to identify any correlation, likely because of our small sample size. The use of EUS-guided transmural drainage, simultaneous transpapillary and transmural drainage, and concomitant debridement was variable among our cohort. Other authors have demonstrated a 90% treatment success rate with a 100% technical success rate with EUS-guided transmural drainage of PFCs after pancreatic tail resection, albeit with only 10 patients.\textsuperscript{18} EUS is particularly useful when there is an absence of luminal compression from the PFC but is not always necessary.\textsuperscript{19} Transmural endoscopic drainage may not be as readily available and requires a greater skill set than percutaneous drainage, though EUS has become more commonly adopted outside of tertiary care centers. Because EUS-guided fine-needle aspiration is commonly performed, the transition to EUS-guided drainage of PFCs should not be difficult, especially for endoscopists who also have ERCP training, though as with any procedure, a learning curve exists.

One important aspect to consider is that these collections, though arising purely from pancreatic duct leaks, may actually contain solid debris due to subsequent incorporation of necrotic tissue, which was enzymatically dissolved by pancreatic juice. So, one potential advantage to endoscopic transmural drainage is the ability to debride necrotic tissue by direct necrosectomy that cannot be evacuated using small bore percutaneous drains.\textsuperscript{20,21} Large diameter balloon dilation of the initial transmural tract allows passage of the endoscope into the cavity to remove solid debris. Indeed, one patient who had unsuccessful percutaneous drainage underwent successful endoscopic debridement as salvage therapy and another patient who had partial resolution after transmural endoscopic placement of a 10 F plastic stent also underwent successful endoscopic debridement. In the latter case, necrotic fat material was removed from the cavity (Fig. 5).

Some have suggested that preoperative prophylactic sphincterotomy and pancreatic stent placement before pancreatic resection can reduce the development of pancreatic fluid collections after pancreatectomy.\textsuperscript{22,23} The largest of these studies examined 25 patients who underwent preoperative pancreatic sphincterotomy and pancreatic duct stent placement, and none developed a pancreatic fistula compared with 5 of 23 in the control group ($p = 0.02$).\textsuperscript{24} This approach appears to reduce the need for endoscopic or percutaneous drainage of PFCs after pancreatic tail resection and may have prevented PFCs seen in our group.

**CONCLUSIONS**

In summary, endoscopic drainage appears to be at least as safe and effective as percutaneous drainage for PFCs arising after pancreatic tail resection. Its lower overall length of hospital stay and use of CT scans make it an important modality in treating this common and difficult complication. A treatment strategy that involves surgeons, endoscopists, and interventional radiologists working together is likely to yield the best outcomes for these patients.

**Author Contributions**

Study conception and design: Azeem, Baron, Topazian, Kendrick

Acquisition of data: Azeem

Analysis and interpretation of data: Azeem, Baron, Topazian, Zhong, Fleming, Kendrick

Drafting of manuscript: Azeem, Baron, Topazian

Critical revision: Azeem, Baron, Topazian

**REFERENCES**