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Case Report

Robotic-Assisted Video-Thoracoscopic Closure of Pancreaticopleural Fistula

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Abstract

Introduction: Pancreaticopleural Fistulae (PPF) are rare communications between the pancreatic duct and the pleural cavity. More commonly the sequelae of alcoholism, PPF occasional results from peripancreatic surgery.

Case presentation: A 26-year-old man had elevated liver enzymes, thrombocytosis, and leukocytosis during postoperative follow-up after splenectomy with en bloc diaphragm resection for Idiopathic Thrombocytosis Purpura (ITP). Abdominal CT scan revealed moderate left pleural effusion and segmental portal vein thrombosis. After Initiation of Intravenous (IV) heparin and left thoracentesis (800 mL), repeat chest imaging studies revealed larger left pleural effusion, right lower lobe pulmonary emboli, and diaphragmatic defect adjacent to intra-abdominal fluid around the pancreatic tail. Percutaneous left pleural catheter drainage revealed elevated intrapleural amylase and lipase levels, confirming pancreaticopleural fistula. Intravenous antibiotics and subcutaneous octreotide (100 mcg TID) were initiated. With the patient in lateral decubitus, robotic-assisted video-thoracoscopic surgery was performed *via* 3 port incisions, including a 4 cm camera port incision, which doubled as an assistant's access port, along the 6th intercostal space at the anterior axillary line and instrument ports along the 3rd intercostal space at the anterior axillary line and along the 9th intercostal space at the posterior axillary line. The diaphragmatic defect edges were freed from intraperitoneal adhesions and closed primarily with absorbable barbed suture, then oversewn with non-absorbable suture, then imbricated with another absorbable barbed suture. Doxycycline pleurodesis was performed. The patient was reinitiated on IV heparin 4 hours postoperatively. Pleural fluid analysis on Postoperative Day (POD)#1 revealed low chest tube outputs and normal amylase levels. He underwent ERCP, sphincterotomy, and pancreatic duct stent placement on POD#4 and required left thoracoscopic evacuation of hemothorax and repeat doxycycline pleurodesis on POD#5, with all chest tubes removed by POD#9. The patient was discharged home on POD#13, tolerating regular diet. Outpatient follow-up at 1 week and at 15 months revealed no recurrent pleural effusion or peripancreatic fluid.

Discussion: Multi-modality approach is often required to successfully manage pancreaticopleural fistulae.

Conclusion: We report the first successful robotic-assisted video-thoracoscopic closure of pancreaticopleural fistula.

Keywords: Robotic surgery; Pancreaticopleural fistula; Intra-abdominal fluid

Introduction

Pancreaticopleural Fistulae (PPF) are rare communications through the diaphragm between a disrupted pancreatic duct and one or both pleural cavities and/or the mediastinum resulting as uncommon sequelae of pancreatitis and are the rare cause of recalcitrant or recurrent pleural effusions. Only 52 cases were identified in a review of the literature published between 1960 and 2007 [1], with 37 of these cases identified in a separate review of the literature published between 1990 and 2004 [2], while 63 adult patients with PPF were identified in the English literature published between 1970 and 2008 [3]. The latest published report of a PPF case was a 15-year-old boy with a presumed episode of pancreatitis, complicated by pseudocyst [4]. While most patients with pancreaticopleural fistulae are alcoholics, only one-half of these patients will have had a clinical history of previous pancreatitis, chronic or acute, which are sometimes due to gallstones or pancreatic carcinoma [3,5-9]. Some patients with PPF may also have pancreatic pseudocysts, which are often recurrent, or a history of pancreatic surgery or pancreatic injury [7,8,10,11]. Pancreaticopleural fistulae are seen in less than 1% of acute pancreatitis cases, 0.4% to 4.5% of chronic pancreatitis cases, and 3% to 17% of cases that include pleural effusion, which indicates a worse prognosis [12,13]. The classic symptoms of PPF are predominantly thoracic or pulmonary symptoms and signs and include the shortness of breath, chest pain, and cough related to alarge, recurrent, and exudative pleural effusion or empyema, which result from the accumulation of pancreatic juices within the pleural cavity due to an abnormal communication with

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the pancreatic ducts [5,8]. Pleural fluid analysis, specifically fluid amylase level, is crucial to diagnosis [14]. Amylase-rich effusion is most commonly caused by malignancy, and was first reported in 1951 in conjunction with lung cancer. Although there were several reports of amylase-rich effusion associated with lymphoma, leukemia, and ovarian and metastatic tumors, only pancreatitis-related PPF has pancreatic-type amylase [15].

Pancreaticopleural fistulae are generally controlled conservatively by allowance of no oral intake, total parenteral nutrition, thoracentesis or chest tube thoracostomy, and somatostatin or octreotide therapy and/or Endoscopic Retrograde Cholangiopancreatogram (ERCP) with sphincterotomy (with or without pancreatic duct stent placement). Successful treatment with radiation therapy has also been reported [16]. Surgical treatment is performed in a small subgroup of these patients in whom conservative therapeutic approaches have failed, often after 1-2 months of unsuccessful medical therapy [3]. While a transabdominal approach can be used for roux-en-Y decompression of the pancreatic duct [17], pulmonary decortication with or without closure of the PPF tract, usually performed through a thoracotomy [18]. We present a case of PPF closed *via* Robotic-Assisted Video-Thoracoscopic (RAVT) approach, in combination with initial decompression of the pleural fluid using a percutaneous transthoracic pigtail catheter, perioperative octreotide therapy, and subsequent ERCP and sphincterotomy.

Case Presentation

A 26-year-old man was admitted due to findings of elevated liver enzymes, thrombocytosis, and leukocytosis during postoperative outpatient follow-up. Two weeks previously, he had undergone a splenectomy for Idiopathic Thrombocytopenic Purpura (ITP) and thrombocytopenia as low as 4000 platelets per microliter (ul) that was associated with bilateral lower extremity petechiae and that was only transiently responsive to 4 days of intravenous steroid therapy with high-dose dexamethasone. After an adequate response to intravenous immunoglobulin (IV-Ig), which increased the platelet count to 222,000 per ul one month after 3 days of IV-Ig, elective splenectomy was performed through a left subcostal incision and required an en bloc resection of an adjacent patch of diaphragm that was densely adherent to the spleen at the splenophrenic ligament. The diaphragm resection was performed with a combination of the Harmonic™ scalpel (Ethicon Endo-Surgery, Cincinnati, OH, USA) and the Ligasure™ device (Medtronic, Minneapolis, MN, USA), and the 3 cm diaphragmatic defect was primarily repaired with horizontal mattress stitches using non-absorbable braided polyester/Dacron sutures (Ethibond™, Ethicon). The splenic hilum was divided near the tail of the pancreas using a linear endostapler with a vascular stapler load (Ethicon Endo-Surgery) and then covered with BioGlue™ (Cryolife, Kennesaw, GA, USA). A Jackson-Pratt drain was placed within the left upper quadrant of the abdomen near the tail of the pancreas and, after no evidence of increased drainage despite the patient being advanced to a regular diet, was removed on postoperative day #5, at which time the patient was discharged to home.

During outpatient follow-up on postoperative day #10, the patient was found to have a thrombocytosis to 1,104,000 platelets per ul, mild leukocytosis to 12.8 k WBC per ul, and mildly elevated serum liver enzyme levels, with alkaline phosphatase 265 units per liter (U/l; normal 38-126 U/l), Aspartate Transaminase (AST) 161 U/l (normal 14-59 U/l), and Alanine Transaminase (ALT) 175 U/l (normal 11-66 U/l). Upon continued outpatient follow-up 5 days later, his thrombocytosis had persisted at 1,134,000 platelets per ul, his leukocytosis had increased to 14.7 k WBC per ul, and his serum liver enzyme levels had increased, with alkaline phosphatase 348 U/l, AST 204 U/l, and ALT 223 U/l. An abdomen CT scan with intravenous contrast was obtained, which showed a moderate left pleural effusion and a segmental portal vein thrombosis in the anterior right hepatic vein. The patient was admitted and initiated on continuous intravenous heparin therapy. A left thoracentesis the following day drained 800 ml of pleural fluid, which were sent for cultures. However, a chest x-ray and a chest/abdomen CT scan with intravenous contrast 4 days later revealed that the pleural fluid had reaccumulated to form a larger left pleural effusion, with the additional finding of right lower lobe pulmonary emboli as well as an apparent diaphragmatic defect adjacent to an intra-abdominal fluid collection around the tail of the pancreas (Figure 1). In retrospect, this diaphragmatic defect was also present on the abdomen CT scan obtained 5 days previously just prior to admission. A percutaneous transthoracic pleural pigtail catheter was subsequently inserted, and 620 ml of pleural fluid were drained. Chemical analysis of the pleural fluid revealed an amylase level of 6320 U/l and a lipase level of 115,285 U/l, confirming the presence of a PPF. The patient was initiated on intravenous broad-spectrum antibiotics and Subcutaneous (SC) octreotide therapy (100 mcg SC TID), and a Thoracic Surgery consultation was requested for possible transthoracic closure of the PPF.

After preoperative evaluation and informed consent, the patient was taken to the operating room 6 hours after cessation of continuous intravenous heparin infusion, with plans for closure of the PPF by primary closure of the diaphragmatic defect, total pleural adhesiolysis and pulmonary decortication to re-expand the atelectatic lung, and chemical pleurodesis with doxycycline to obliterate the pleural space by pleural symphysis. After induction of general anesthesia and placement of a dual-lumen endotracheal tube for single-lung ventilation, a RAVT approach, using the da Vinci® "S"™ robotic surgical system (Intuitive Surgical Corp., Sunnyvale, CA, USA), was chosen, with the option for a latissimus and serratus muscle-sparing posterolateral thoracotomy, if needed. A 4 cm port incision, to be used as a combination robotic camera port and surgical assistant's utility port, was created along the 6th Intercostal Space (ICS) at the anterior axillary line, and finger dissection was performed to bluntly divide the immediately adjacent pleural adhesions. Using a 30-degree-up robotic thoracoscope for intrapleural visualization, a 1 cm robotic instrument port was created along the 3rd ICS at the anterior axillary line and a 1.5-c,m robotic port was created along the 9th ICS at the posterior axillary line (Figure 2). Prior to docking of the robotic patient cart to the three ports, a multi-level intercostal analgesia infusion catheter (On-Q® Silver Soaker™ Catheter, Avanos, Alpharetta, GA, USA) was tunneled extrapleurally from the 10th ICS to the 2nd ICS, and a bolus of 30 ml of 0.5% bupivacaine was infused to initiate a multi-level intercostal nerve block. Evacuation of intrapleural fibrinous debris was then performed, with attention focused mainly along the posterolateral costophrenic recess and between the left lung's lower lobe base and the diaphragm in order to uncover the diaphragmatic defect, which was the pleural opening to the PPF.

The diaphragmatic defect was identified along the posterolateral aspect of the dome of the left hemidiaphragm, and the serosa of the underlying gastric fundus was clearly visible through this defect, as predicted by the preoperative CT scan. The diaphragmatic defect edges were found to be relatively free of intraperitoneal adhesions, at least for several millimeters, along the medial, anterior, and lateral

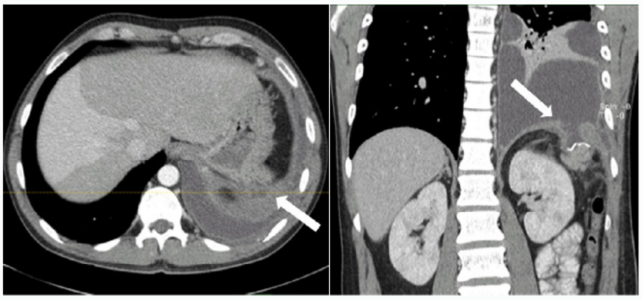

Figure 1: Computerized tomography axial image (left panel) and coronal image (right panel) showing the pancreaticopleural fistula (arrows) through the left hemidiaphragm between the underlying pancreatic tail staple line and the overlying left pleural cavity.

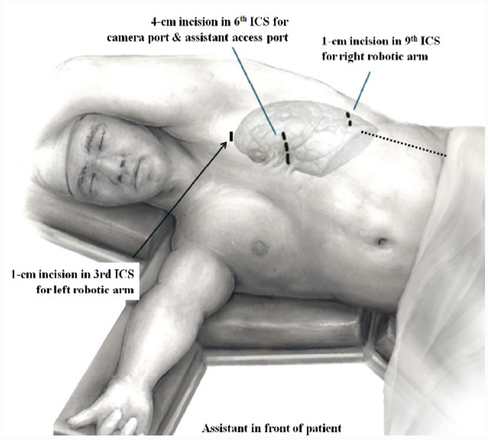

Figure 2: Port placement for left robotic-assisted video-thoracoscopic repair of pancreaticopleural fistula showing a 4.5 cm camera port along the 6th Inter-Costal Space (ICS) at the anterior axillary line, which doubled as the assistant's access port, a 1 cm instrument port along the 3rd ICS at the anterior axillary line, and a 1.5 cm instrument port along the 9th ICS at the posterior axillary line.

edges, but the posterior edge was densely adherent to the staple line at the tail of the pancreas. Weakening of the diaphragmatic parietal pleura, after having bathed in pancreatic secretions for several days, was confirmed by its inability to hold a suture, after a trial simple-interrupted stitch was placed using robotic needle holders and a non-absorbable braided suture placed full-thickness through the anterior edge of the diaphragmatic defect but only partial-thickness through the posterior edge of the diaphragmatic defect.

Using a robotic curved bipolar dissector, the posterior edge of the diaphragmatic defect was freed from the underlying intraperitoneal adhesions until 1 cm of diaphragm with intact peritoneum was freed circumferentially around the diaphragmatic defect. Another trial simple-interrupted stitch, using the robotic needle holders and the non-absorbable braided suture placed full-thickness, including the peritoneum, at both the anterior and the posterior edges of the diaphragmatic defect, resulted in reapproximation of the diaphragmatic defect edges across the widest gap of the diaphragmatic defect without the suture pulling through the diaphragm and peritoneum.

Closure of the diaphragmatic defect was then performed using a running horizontal-mattress stitch using the robotic needle holders and an absorbable end-looped, barbed suture (V-Loc™, Medtronic) (Figure 3) placed 1 cm from the edges of the diaphragmatic defect and starting and ending 1 cm beyond the extent of the diaphragmatic defect. This first suture line was then oversewn with a running simple stitch using a non-absorbable braided suture (Ethibond). The diaphragm was then imbricated over this second suture line using a running simple stitch with two other absorbable end-looped, barbed sutures (V-Loc) that overlapped at the midpoint of the diaphragmatic defect repair.

Figure 3: Illustration of a V-Loc™ suture (Medtronic, Minneapolis, MN, USA) showing the end-loop (left and right panel) and the barbs along the length of the suture (right panel).

Total pleural adhesiolysis and pulmonary decortication and subsequent evacuation of the remaining intrapleural fibrinous debris and loculated pleural effusions was then performed using the robotic thoracic grasper and the robotic fenestrated grasper to bluntly divide the diffuse pleural adhesions, to free the intrapleural fibrinous debris from the chest wall parietal pleura, and to decorticate the pulmonary visceral pleura peel. After intrapleural irrigation with 3 liters of sterile water using a battery-powered endoscopic irrigator and evacuation of the intrapleural debris and fluid using a 10-mm endoscopic suction tip, chemical pleurodesis was then performed by spraying 1000 mg of doxycycline in 100 ml of saline throughout the left pleural cavity and over the entire visceral pleura of the left lung. A 32-Fr straight chest tube was then placed through the 6th ICS port incision and along the anterior mediastinum to the apex of the left pleural cavity, a 32-Fr angled chest tube was then placed through the 9th ICS port incision and over the diaphragm to the posterior costophrenic recess, and another 32-Fr straight chest tube was placed through a separate stab incision posterior to the initial 9th ICS port and directed along the costovertebral gutter to the apex of the left pleural cavity. The left lung was fully re-inflated as the robotic patient cart was undocked, and the 6th and 3rd ICS ports were closed in anatomic layers with absorbable sutures.

The patient was able to be extubated in the operating room prior to transfer to the post-anesthesia care unit and subsequent overnight monitoring in the intensive care unit. Broad-spectrum antibiotics and octreotide therapy were resumed, and intravenous heparin therapy was reinitiated 4 hours postoperatively. Analgesia was provided *via* the multi-level intercostal analgesia infusion catheter (On-Q), with a basal infusion of 4 ml/hr of 0.25% bupivacaine and a demand infusion of 2 ml of 0.25% bupivacaine every 15 min as needed using a patient-controlled analgesia pump. The patient was allowed to have a clear liquid diet and advanced to a regular diet as tolerated. A sample of pleural drainage from the angled chest tube, which had drained 300 ml overnight, was chemically analyzed on postoperative day #1 and found to have an amylase level of <39 U/l and a lipase level of <19 U/l (Figure 5). The patient was transferred to the telemetry ward on postoperative day #1, ambulated, and only had 75 ml of total pleural drainage through all three chest tubes combined over 24 hr during the 2nd postoperative day, with posterior-anterior and lateral chest x-rays revealing no reaccumulation of pleural fluid on postoperative day #2.

The patient underwent ERCP, sphincterotomy, and pancreatic duct stent placement on postoperative day #4 (Figure 4). Unfortunately, he was found to have developed coincidentally a left hemothorax that same day and underwent a left Video-Assisted Thoracoscopic (VATS) evacuation of hemothorax, total pleural adhesiolysis and pulmonary decortication, and repeat doxycycline chemical pleurodesis on postoperative day #5. He also developed a mild pancreatitis that was confirmed on post-ERCP day #4, with serum lipase levels peaking at 1065 U/l on post-ERCP day #5 and which subsequently improved (Figure 5). There was no recurrence of hemothorax despite reinitiation of the continuous intravenous heparin therapy 8 hours after the VATS evacuation of hemothorax, and all of his chest tubes were able to be removed by postoperative day #9 (post-ERCP day #5). The patient's anticoagulation was subsequently transitioned to daily subcutaneous dalteparin (Fragmin) on postoperative day #11, and the patient was able to be discharged to home on postoperative day #13, tolerating a regular diet. He has survived with no evidence of recurrent PPF for at least 5.2 years after his PPF repair.

Discussion

Video-assisted thoracoscopy has been successfully used as the surgical approach of choice for diaphragmatic plication of a paretic hemidiaphragm since the first such case was reported in adults in 1996 and in children in 1998. Diaphragm resection with simultaneous primary repair using linear endostapling devices has also been performed using a VATS approach for diaphragmatic fenestrations in cases of catamenial spontaneous pneumothoraces. Robotic-assisted laparoscopic diaphragmatic resection for tumor, with primary diaphragmatic repair using suture, has been reported in a case of metastatic ovarian carcinoma. Congenital diaphragmatic hernias have also been repaired *via* both RAVT and robotic-assisted laparoscopic approaches.

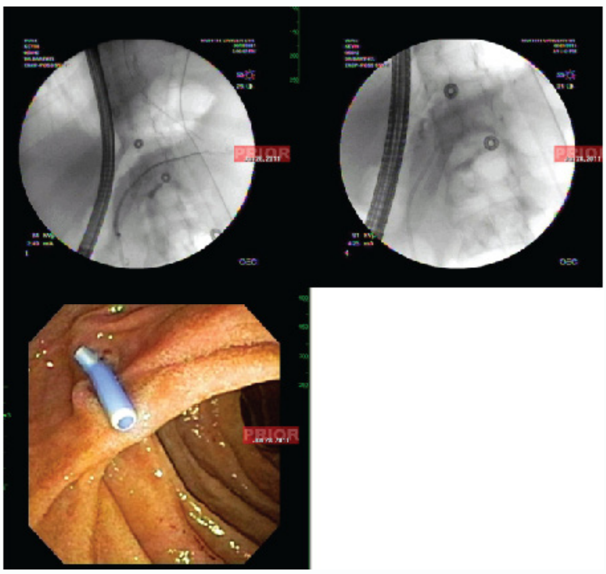

Figure 4: Fluoroscopic images (upper panels) showing Endoscopic Retrograde Cholangiopancreatogram (ERCP) (left upper panel) and pancreatic duct stent placement (right upper panel). Endoscopic image (lower panel) showing the pancreatic duct stent through the ampulla of Vater.

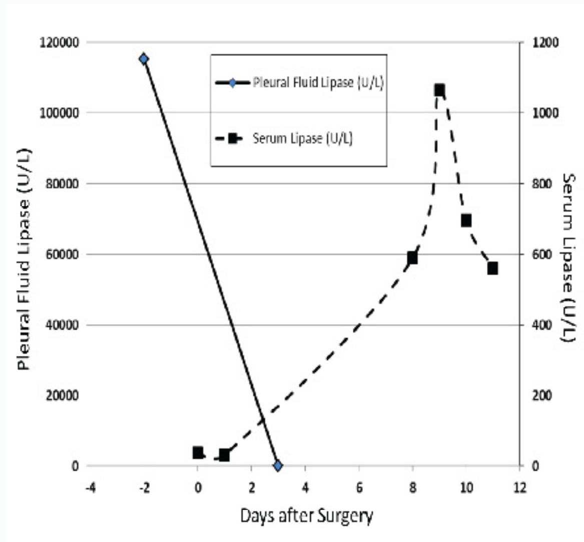

Figure 5: Graph of left pleural fluid lipase levels (diamonds; solid line) and serum lipase levels (squares; dashed line) as a function of days before and after Robotic-Assisted Video-Thoracoscopic (RAVT) repair (day 0) of pancreaticopleural fistula.

As the majority of patients with PPF present primarily and predominantly with dyspnea or respiratory distress (65%), cough (27%), chest or back pain (23%), or other thoracic rather than abdominal (29%) symptoms, initial diagnosis is often obscured or delayed, although initial treatment involves transthoracic drainage of the pleural effusion [11,19,20]. Detection of high amylase and lipase levels by chemical analysis of pleural fluid indirectly diagnoses the presence of a PPF, although pleural effusions associated with acute pancreatitis, esophageal perforation, and thoracic malignancy are important to consider in and exclude from the differential diagnosis [5,7,19]. While ERCP and the occasional intraoperative pancreatogram have been considered the gold standards and better for identifying actual PPF than CT scans [1,2,11,16,17,21], ERCP may fail to demonstrate the PPF despite showing pancreatic ductal changes characteristic of chronic pancreatitis [19]. Preoperative CT scans can demonstrate a PPF, but may be limited to fluid-containing PPF, as in the present case and as reported by others [10,18,19], although CT scans may demonstrate other peripancreatic abnormalities, such as intraabdominal or mediastinal pseudocysts [5,19,22,23]. Magnetic Resonance (MR) imaging with MR Cholangiopancreatography (MRCP), alone or in combination with CT scans, may also detect a PPF with or without complete main pancreatic duct obstruction [1,7,9,12,19,23,24], as might ultrasonography in addition to showing a pseudocyst [25].

Once identified, smaller PPF may not require primary closure and can generally be controlled conservatively by a 2- to 4-week trial medical therapy, including bowel rest with no oral intake, Total Parenteral Nutrition (TPN), thoracentesis or chest tube thoracostomy, and possibly somatostatin or octreotide therapy and/or Endoscopic Retrograde Cholangiopancreatogram (ERCP) with sphincterotomy (with or without pancreatic duct stent or nasopancreatic drain placement) [1,2,5,7,9,10,26-28]. In patients who have had surgically-altered anatomy, such as the patient who had a prior subtotal gastrectomy, with roux-en-Y gastrojejunostomy, and who subsequently develop a PPF may be treated successfully with a laparoscopy-assisted transjejunal ERCP [29]. Successful treatment of a PPF with radiation therapy has also been reported [16], and a large, right chronic pancreatitic pleural effusion has been successfully treated by percutaneous catheter drainage of an abdominal pancreatic pseudocyst that had extended into the mediastinum, after conventional closed-chest tube thoracostomy drainage failed to empty the pleural space [30]. The major complication in patients with PPF is super infection, which results in significant morbidity and mortality [5,28].

Surgical treatment is performed in a small subgroup of these patients in whom conservative medical therapeutic approaches, including endoscopic intervention with pancreatic duct stent placement or percutaneous catheter pseudocyst drainage, have failed [1,2,8,10,23,27,30]. Failure of medical therapy includes failure of pleural effusion(s) to clear, recurrence of pleural effusion(s) after reinstatement of oral intake, or superinfection. Interestingly, total duration of therapy for patients in whom operative intervention was required after failed medical management was greater than the total duration of therapy for patients who underwent surgery alone, and operative treatment was successful more often than medical therapy alone [3]. A transabdominal operation, with a Frey's lateral, Parlington-Rochelle, or Puestow-Gillesby longitudinal pancreaticojejunostomy or with roux-en-Y bypass procedure, can be performed in order to restore anatomic continuity and decompress the pancreatic duct [1,10,17,31], or any recurrent pseudocysts [11] or for pain relief [28]. Pylorus-preserving pancreaticoduodenectomy or distal pancreatectomy have also been reported as the operative treatment of a PPF [8,9,23]. A PPF is generally closed, if at all, *via* a thoracotomy approach, although the usual reasons for any intrapleural intervention include drainage of intrapleural pancreatic secretions that are often multi-loculated, evacuation of hemothorax, intrapleural fibrinous debris, or empyema, and pulmonary decortication in order to allow re-expansion of the lung that is often trapped due to a fibrinous visceral pleural peel [18]. We report a case of PPF successfully closed *via* a RAVT approach to primarily close the diaphragmatic defect that is the pleural end of the PPF, as well as to evacuate the intrapleural fibrinous debris and multi-loculated pleural effusion, to completely divide all the pleural adhesions and decorticate the entire left lung, to instill intrapleural doxycycline for chemical pleurodesis, and to place adequate pleural drains.

Conclusion

While smaller PPF may not require primary closure and may not even be identifiable during exploration of the pleural cavity after evacuation of intrapleural debris and pulmonary decortication, primary closure of larger diaphragmatic defects and, thus, the pleural ends of larger PPF by itself is often unsuccessful, even when performed *via* thoracotomy. Closure of the pleural end of PPF with a pedicled intercostal muscle flap has, therefore, been proposed. In the present case, we performed a chemical pleurodesis using doxycycline in order to induce pleural symphysis to reinforce the primary diaphragmatic repair in lieu of muscle flap reinforcement. However, successful treatment of PPF has usually required the combination of a transthoracic surgical approach with somatostatin (or synthetic analog octreotide) administration, which reduces both basal and stimulated pancreatic exocrine secretions, and endoscopic sphincterotomy and pancreatic duct stent placement, which creates the path of lowest resistance for pancreatic secretions to exit the pancreatic ducts preferentially into the small intestines rather than into the negative-pressured pleural cavity or the immediately-adjacent retroperitoneal tissues. In addition, narcotic usage postoperatively was minimized by the use of continuous multi-level intercostal nerve block infusion of the local anesthetic, bupivacaine, *via* the tunneled extrapleural soaker catheter placed intraoperatively, thereby minimizing any narcotic-induced closure of the sphincter of Oddi. Thus, we report a case in which a post-splenectomy PPF was successfully managed with a multi-modality approach using octreotide therapy, endoscopic decompression of the intraductal pancreatic secretions, local anesthetic for continuous intercostal nerve block to minimize the untoward narcotic effect on the sphincter of Oddi, and the first report of RAVT closure of the diaphragmatic defect that is the pleural end of the PPF.

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Informed consent: Permission was obtained from the patient for publication of this case report and any accompanying images for education purposes as part of our institutional surgical informed consent. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

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Conflict-of-Interest (COI) Disclosures

E.M.T. has had a financial relationship with Intuitive Surgical Inc. in the form of honoraria as a robotic thoracic surgery proctor and observation site. C.M.S. (now MD) is currently a physician in the Department of Emergency Medicine at Florida Hospital-Tampa in Tampa, FL, USA. None of the other authors have any COI to disclose.

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