

# Techniques of Pancreatic Resection for Cancer

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Pancreatic resection and reconstruction remain a therapeutic challenge to surgeons treating neoplastic disease of the pancreas, distal common bile duct, ampulla of Vater, and proximal duodenum. Despite appreciable improvements in perioperative, postoperative, and intraoperative techniques, morbidity for these procedures remains high. The majority of this morbidity is attributed to pancreatic reconstruction and subsequent anastomotic and pancreatic leaks.

## HISTORICAL BACKGROUND

The first reported resection of a pancreatic tumor was a distal pancreatectomy for a spindle cell sarcoma performed by Friedrich Trendelenburg in 1882.<sup>1</sup> Despite a postoperative course complicated by wound infection and malnutrition, the patient was discharged home upon his own insistence only to die a few weeks later secondary to acute respiratory failure.<sup>2</sup> Halsted described the first successful resection of a periampullary tumor in 1898 when he performed a local resection along with an anastomosis of the pancreatic duct and bile duct to the duodenum for a patient with obstructive jaundice.<sup>3</sup> Indeed, most early reports of periampullary tumor resection were performed via a transduodenal approach. That same year, Alessandro Codivilla performed the first pancreaticoduodenectomy in a 46-year-old male with a pancreatic head mass; however, the patient died on postoperative day 18.<sup>4</sup> Walther Kausch<sup>5</sup> performed the first successful two-stage pancreaticoduodenectomy in 1909, followed by Hirschel<sup>6</sup> in 1914, who reported the first successful one-stage pancreaticoduodenectomy. By 1910, 20 pancreatic resections were reported in the literature with a 45% in-hospital mortality rate.<sup>2</sup>

General acceptance for the pancreaticoduodenectomy was not seen until Whipple reported his successful two-stage pancreaticoduodenectomies in 1935.<sup>7</sup> Five years later he performed the first anatomic one-stage pancreaticoduodenectomy for a tumor of the head of the pancreas, where he performed an antrectomy and complete removal of the duodenum.<sup>2,8</sup> The first one-stage pancreaticoduodenectomy in the United States was performed by Trimble in 1941.

Despite numerous technical advances over the next 40 years, morbidity and mortality remained high, 40% to 60% and 20% to 40%, respectively. However, the combination of centralization of pancreatic surgery, as well as the technical advancements led by John Cameron after 1980, resulted in improved outcomes, particularly with mortality, and subsequent widespread acceptance of the procedure.<sup>9</sup>

## PREOPERATIVE EVALUATION

One of the most important elements in the preoperative evaluation of a patient with pancreatic cancer is determining resectability. This involves evaluation of both clinical and anatomic parameters, ranging from patient performance status to local tumor relationships relative to major vascular structures. Clinical evaluation involves a thorough history and physical examination. History should focus specifically on a personal and family history of pancreatitis or malignancies, such as pancreatic, colon, or breast cancer. Physical examination should look for evidence of advanced disease, such as palpable metastatic disease in the supraclavicular fossa (Virchow node), palpable periumbilical node (Sister Mary Joseph node), palpable perirectal mass (Blumer shelf), ascites, weight loss, and cachexia. Hepatomegaly and a palpable gallbladder (Courvoisier sign) may signify chronic biliary obstruction. Routine laboratory screening (including complete blood count, electrolyte panel, liver function tests, coagulation panel, and albumin) alerts the clinician to anemia, hyperbilirubinemia, and evidence of new-onset diabetes, pancreatitis, and malnutrition. Pertinent serum tumor markers include carbohydrate antigen 19-9 (CA 19-9) and carcinoembryonic antigen (CEA). Of note, CA 19-9 levels are often elevated in setting of biliary inflammation or obstruction, even among patients with benign disease. Accordingly, its low sensitivity (80%) and specificity (60% to 70%) for pancreatic ductal adenocarcinoma make it unsuitable for use as a screening tool but can be useful when trends are assessed, particularly in determining response to therapy.

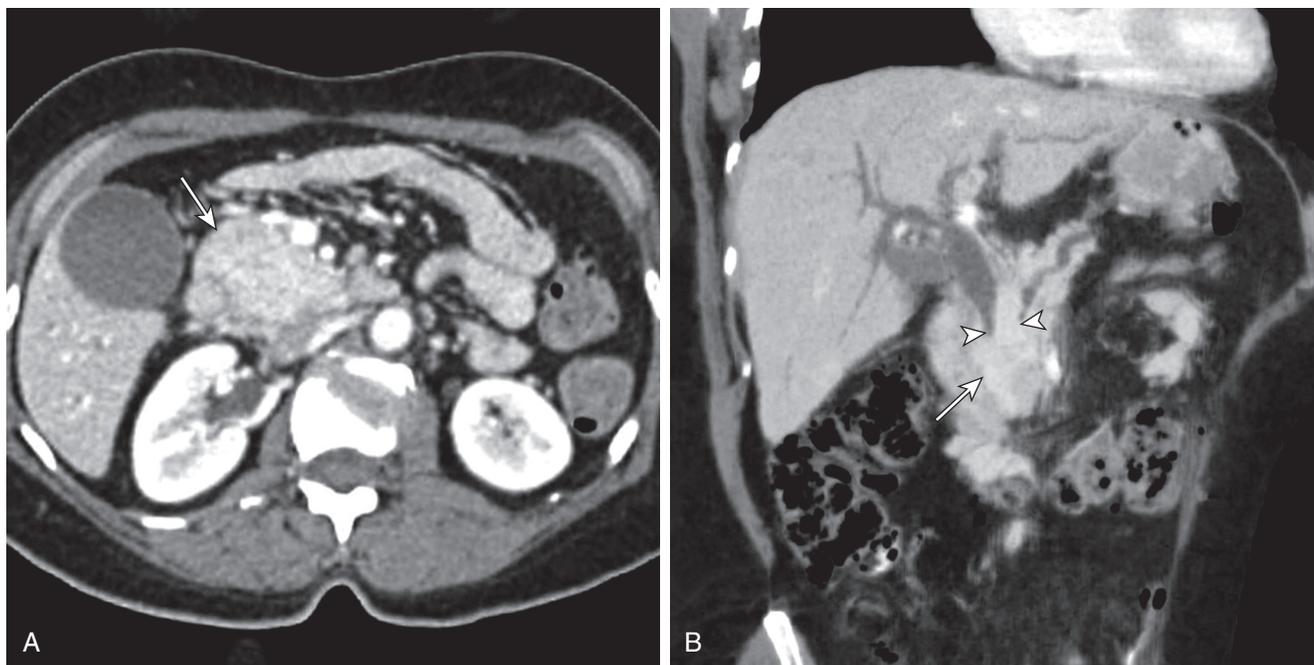
Appropriate preoperative imaging is essential to assess resectability of pancreatic tumors. Specifically, identification of distant metastases and locally advanced pancreatic tumors involving major vascular structures is paramount. Multiple preoperative imaging modalities are used; however, in most centers, contrast-enhanced pancreas protocol spiral computed tomography (CT) is the preferred modality (Fig. 100.1). Liver lesions greater than 1 cm in size are easily identified. The role of positron emission tomography–CT (PET-CT) in pancreatic cancer remains poorly defined but may be useful in ruling out distant metastatic disease in patients with suspicious lesions. Tumor encasement of the celiac axis or superior mesenteric artery or occlusion/unreconstructible portal vein (PV) and superior mesenteric vein (SMV) tumor involvement is considered locally advanced disease, and nonsurgical options, such as chemotherapy and chemoradiation, are preferred in these instances. Three-dimensional (3D) reconstruction of the mesenteric vessels both in the arterial

**ABSTRACT**

Pancreatic cancer poses a significant therapeutic challenge to surgeons. Surgery remains the only chance at long-term survival. Proper patient selection and multidisciplinary approaches are of utmost importance. More aggressive surgical approaches, including vascular resection and multivisceral resection, have demonstrated acceptable outcomes and have allowed for an increased number of patients to be considered for surgery. Despite marked improvements in surgical techniques, further progress is needed to improve survival. Pancreatic surgeons should continue to play a key role in identifying more effective therapies for this disease.

**KEYWORDS**

pancreatic cancer; technical aspects; pancreas; periampullary; distal pancreatectomy; pancreatoduodenectomy



**FIGURE 100.1** A 57-year-old female with history of pancreatic adenocarcinoma. (A) Axial computed tomography image of the abdomen obtained in the venous phase demonstrates a large mass in the region of the head of the pancreas (arrow). (B) Minimum intensity projection in the coronal plane better demonstrates the pancreatic mass (arrow), resulting in a “double duct” sign (arrowheads). (Courtesy Ihab Kamel, MD, and Mounes Ghasebeh, MD, Department of Radiology, The Johns Hopkins University School of Medicine.)

and venous phases can preoperatively aid in demonstrating critical anatomic relationships. In addition, 3D CT helps identify surgically relevant aberrant anatomy, such as a replaced right hepatic artery.

The use of endoscopic ultrasound (EUS) for preoperative evaluation is center dependent. The ability of EUS to predict vascular involvement remains controversial. Moreover, the procedure is operator dependent and not particularly useful in the determination of distant metastatic disease. Its main utility is in obtaining a tissue sample via fine-needle aspiration, particularly in patients with locally advanced/unresectable disease prior to beginning chemotherapy. Biopsy is associated with a low incidence of complications, and it is generally reserved for unresectable lesions or patients who may benefit from neoadjuvant therapy prior to resection. Preoperative biliary decompression is associated with increased wound infections and prolonged hospital stay but may be beneficial for malnourished patients or those presenting with jaundice/cholangitis in whom surgery may be delayed.<sup>10–12</sup>

## TECHNIQUES OF RESECTION

### PANCREATICODUODENECTOMY

#### Resection

Endotracheal intubation is necessary. Central venous catheters and invasive arterial monitoring lines are inserted as needed, with peripheral venous access typically being sufficient. A nasogastric tube is placed and preoperative antibiotic prophylaxis, as well as deep venous thrombosis prophylaxis, is administered. The patient is positioned in the supine position.

The first step of the procedure is to determine resectability and rule out distant disease. Routine use of staging laparoscopy remains controversial. Some surgeons use it routinely, whereas others prefer to use staging laparoscopy only in select cases when there is a higher probability of metastatic disease, such as adenocarcinoma of body and tail of the pancreas or in the setting of high CA 19-9 levels.<sup>13–15</sup> With the increased sensitivity of modern imaging techniques, many surgeons argue that staging laparoscopy has a low yield, making it less necessary.

Many surgeons prefer an upper abdominal midline incision; however, a bilateral subcostal incision may also be used. The abdomen is explored for evidence of metastatic disease. This exploration includes the liver, peritoneum, omentum, transverse mesocolon, and all serosal surfaces. Involvement of periportal and celiac axis lymph nodes or involvement of the base of the transverse mesocolon is not necessarily a contraindication to resection. The base of the transverse mesocolon may be taken with the specimen, including a segment of the middle colic artery when necessary, given that the marginal artery generally maintains blood supply to the transverse colon.

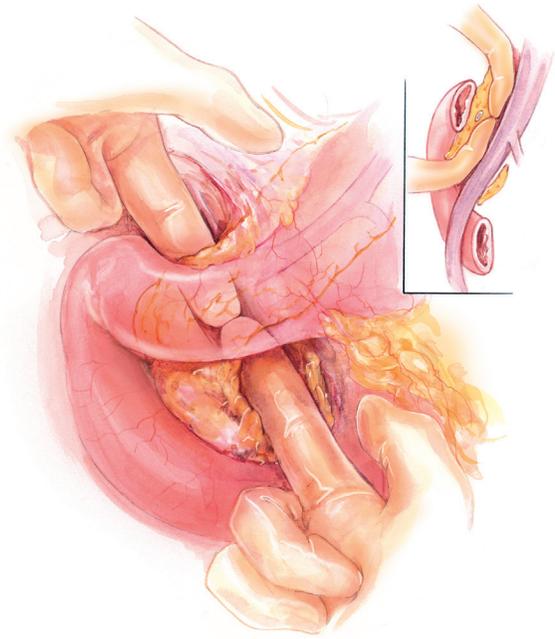
A wide Kocher maneuver is performed to evaluate local major vascular relationships. Of note, preoperative cross-sectional imaging offers the most accurate assessment of the relationship of the tumor to the vessels, especially the superior mesenteric artery. With mobilization of the duodenum, one can assess whether there is a component of uncinete process involvement with the superior mesenteric artery. In addition, this maneuver allows the surgeon to evaluate for tumor extension into the inferior vena cava and aorta. Next, the common hepatic artery and proper hepatic artery are assessed to confirm

resectability. The PV SMV confluence is also assessed for tumor involvement. The hepatoduodenal ligament is incised. The common hepatic duct is identified and divided close to the level of the cystic duct. A more proximal margin on the hepatic duct is sometimes needed for superior pancreatic tumors arising from the head of pancreas. Assessment for a replaced right hepatic artery, typically located lateral and posterior to the common bile duct, is imperative, and the artery should be protected when identified. A replaced hepatic artery should also be readily visible with state-of-the-art preoperative imaging. When an accessory right hepatic artery is present (i.e., a right hepatic artery traveling lateral and posterior to the common bile duct in the presence of a native right hepatic artery), the accessory replaced right hepatic artery can often be ligated with impunity. Rarely, a completely replaced common hepatic artery may be seen originating from the superior mesenteric artery (type IX anatomy); recognition, preservation, or reconstruction of this vessel is critical.

After defining the arterial anatomy, the gastroduodenal artery (GDA) is identified and test clamped to ensure adequate flow in the proper hepatic artery. In instances in which the celiac axis is partially or completely occluded, the hepatic artery flow may be dependent on the GDA. If a weak pulse is noted in the hepatic artery at test clamping, division of the median arcuate ligament is a feasible option to diminish stenosis or occlusion of the celiac axis. After confirming an adequate pulse in the proper hepatic artery, the GDA is ligated and divided. The anterior PV can now be dissected free from the posterior surface of the neck of the pancreas. For a classic Whipple, a distal gastrectomy is performed, which includes ligation of the right gastric artery. For pylorus-preserving pancreaticoduodenectomies (PPPDs) the first portion of the duodenum is divided 3 cm distal to the pylorus. Numerous studies comparing classic Whipple and PPPD have reported no major differences in morbidity or survival. However, other studies have noted decreased delayed gastric emptying (DGE) with classic Whipple compared with less operative time, operative blood loss, and red blood cell transfusion for patients undergoing PPPD.<sup>16,17</sup>

Attention is then turned to the third and fourth portions of the duodenum. This portion of the duodenum is adequately mobilized, allowing for the anterior surface of the SMV to be dissected free. The right gastroepiploic vein and artery are identified and ligated. Cephalad dissection off the anterior surface of the SMV avoids venous branches and ultimately clears a plane anterior to the PV and SMV, posterior to the neck of the pancreas (Fig. 100.2). The transverse pancreatic arterial arcade is controlled with four 3-0 silk stay sutures placed superiorly and inferiorly. The pancreatic neck is slowly transected using electrocautery. The duct is identified and transected with a scalpel when possible. The jejunum is divided distally, approximately 15 to 20 cm distal to the ligament of Treitz. The mesentery is carefully divided, and the proximal jejunum and fourth portion of the duodenum are passed posterior to the mesenteric vessels to the right of the operative field.

The specimen now remains attached by the remaining attachments of the head and uncinete process, which are



**FIGURE 100.2** Creation of the tunnel behind the neck of the pancreas with cephalad dissection off the anterior surface of the superior mesenteric vein avoids venous branches and ultimately clears a plane anterior to the portal vein and superior mesenteric vein, posterior to the neck of the pancreas. (Image drawn by Corinne Sandone, MA, CMI. From Cameron JL, Sandone C. *Atlas of Gastrointestinal Surgery*. Vol 1. 2nd ed. Shelton, CT: People's Medical Publishing House; 2014:290. Used with permission from PMPH-USA, LTD, Shelton, CT.)

subsequently separated from the SMV and SMA through sharp dissection, and serial division of retroperitoneal tissue along the superior mesenteric artery with an electronic dissector (e.g., harmonic scalpel, LigaSure device). The dissection should remain flush with the mesenteric vessels to ensure pancreatic tissue and lymph nodes are excised in their entirety. The specimen consists of the distal stomach or first portion of the duodenum, neck, head, and uncinete process of the pancreas, gallbladder, distal biliary tree, and approximately 10 cm of the jejunum. The pancreatic neck, bile duct, and retroperitoneal margins are marked for intraoperative frozen section. Alternatively, the common hepatic duct and pancreatic neck margins can be sent for examination earlier in the procedure while the main specimen is removed.

### Vascular Resection

En bloc resection to include the PV or SMV in pancreatic cancer was first proposed by Fortner in 1973.<sup>18</sup> With the increasing use of neoadjuvant therapies, PV and SMV resection in borderline resectable pancreatic tumors is increasingly being performed. State-of-the-art cross-sectional imaging is very accurate in identifying vascular involvement; as such, the surgeon should rarely be caught off guard and should be prepared for the possibility of vascular reconstruction. Adequate proximal and distal control is obtained by mobilization of the PV and SMV. Primary anastomosis is generally possible for short segment resections (<3 to 4 cm) after adequate mobilization of

the portal and SMV (and sometimes the liver itself). For long segment reconstruction, interposition grafts are used, including cadaveric vein or autologous vein, such as the internal jugular or left renal vein.

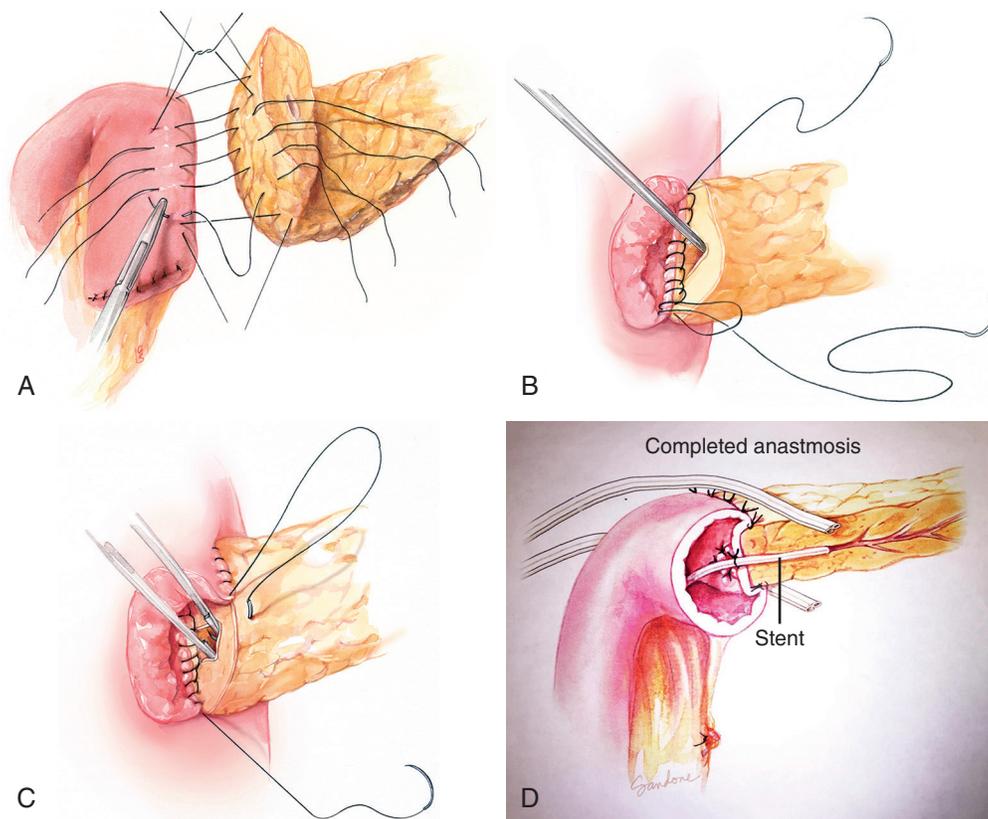
Arterial encasement of the superior mesenteric artery, hepatic arteries, or celiac axis is generally accepted as a contraindication to resection. However, visceral arterial resections with or without vein resections have been reported.<sup>19</sup> Unlike the outcomes among patients undergoing PV, which have been demonstrated to be comparable to Whipple without vascular resection, visceral artery resection may be associated with worse short- and long-term outcomes. Therefore vascular resection in pancreatic cancer should be used very selectively, being largely restricted to patients who have received neoadjuvant chemotherapy/chemoradiation. In addition, such complex operations should be performed only at experienced centers. In general, outcomes after arterial resection remain disappointing and should therefore not be considered a standard approach, although arterial resection may be beneficial in select cases.

### Reconstruction

After closing the defect at the previous ligament of Treitz, reconstruction begins with delivering the jejunum through a rent in the bare area of the transverse mesocolon to

the right of the middle colic vessels. The pancreatoenteric reconstruction is responsible for the majority of morbidity associated with the Whipple procedure. Numerous variations of this anastomosis exist. We prefer a duct-to-mucosa anastomosis beginning with a back row of 3-0 silk sutures incorporating the pancreatic capsule and a seromuscular bite of the jejunum. A small jejunostomy in similar dimension to the pancreatic duct is created. A duct-to-mucosa anastomosis with interrupted 5-0 PDS sutures is performed incorporating the pancreatic duct and the full thickness of the jejunum. A 3.5- to 5-mm pediatric feeding tube (depending on the size of the duct) can be used as a pancreatic stent and left in place. Upon completion of the duct-to-mucosa anastomosis, an anterior row of interrupted 3-0 silk Lembert sutures completes the two-layer anastomosis.

Another method of pancreatoenteric reconstruction is the invagination technique, which can be accomplished in an end-to-side or end-to-end fashion. When an invagination technique is used, we prefer the end-to-side technique. Initially, the pancreatic remnant is mobilized for 2 to 3 cm. A back row of interrupted 3-0 silk sutures is placed, followed by a jejunostomy along the length of the pancreatic neck (Fig. 100.3A). The inner posterior layer is made using running 3-0 absorbable sutures, incorporating the pancreatic capsule, cut portion of pancreas, and



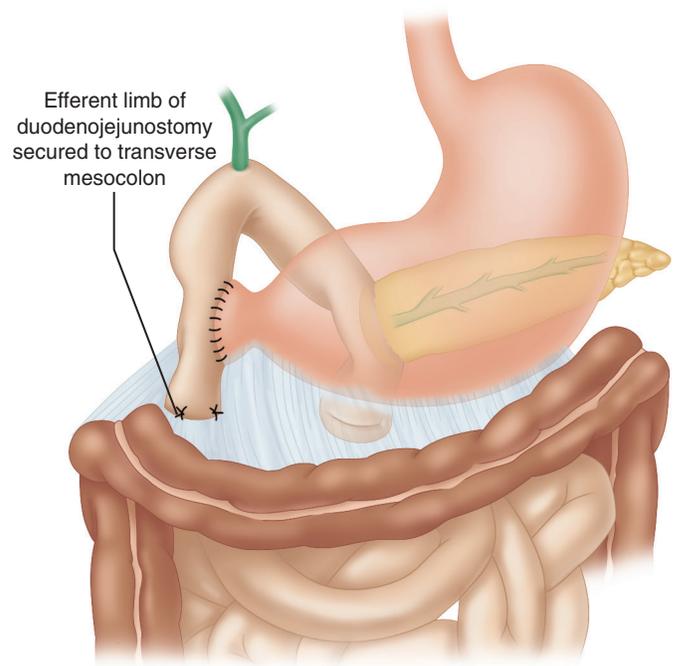
**FIGURE 100.3** (A–D) Pancreaticojejunostomy technique beginning with (A) the outer layer of the posterior row followed by (B) inner layer of posterior row and (C) the inner layer of anterior row. (D) Final reconstruction of pancreaticojejunostomy with drains in place. ([A–C], Images drawn by Corinne Sandone, MA, CMI. From Cameron JL, Sandone C. *Atlas of Gastrointestinal Surgery*. Vol 1. 2nd ed. Shelton, CT: People’s Medical Publishing House; 2014:294–295. Used with permission from PMPH-USA, LTD, Shelton, CT; [D], From Cameron JL, He J. Two thousand consecutive pancreaticoduodenectomies. *J Am Coll Surg*. 2015;220:530–536.)

full thickness of the jejunum (Fig. 100.3B). When possible, the pancreatic duct should be included in several throws of the running stitch to create a duct-to-mucosa anastomosis. The anterior layer of the inner row is performed in a similar fashion, being sure to include the pancreatic duct when possible, with careful attention to not inadvertently occlude the duct (Fig. 100.3C). Finally, an anterior row of interrupted 3-0 silk Lembert sutures is placed, bringing the jejunum over to cover the anastomosis (Fig. 100.3D).

Pancreatogastrostomy is performed in a similar fashion with the pancreas invaginated into the posterior wall of the stomach. Menahem et al. performed a meta-analysis of randomized controlled clinical trials comparing pancreaticogastrostomy with pancreaticojejunostomy.<sup>20</sup> These authors reported a lower incidence of pancreatic and biliary fistulas with pancreaticogastrostomies; however, other randomized controlled trials and metaanalyses have failed to demonstrate superior outcomes for using pancreaticogastrostomy. Heterogeneity in surgical techniques and definition of pancreatic fistula and complications complicate such analyses.<sup>21,22</sup> Both approaches are acceptable and depend on surgeon experience and preference.

The approach to the biliary anastomosis is less variable. We prefer a single layer of interrupted 4-0, 5-0, or 6-0 PDS sutures (depending on the duct size), located 5 to 10 cm distal to the pancreaticojejunostomy. The posterior row is performed by placing the sutures inside out on the jejunum and outside in on the hepatic duct, leaving the knot inside the anastomosis. The posterior row sutures are secured with clamps until all posterior row sutures are placed. These sutures are then knotted and the anterior row is placed outside in on the jejunum and inside out on the hepatic duct. Previously placed biliary stents may be included in the anastomosis.

Reconstruction of gastrointestinal continuity involves either a gastrojejunostomy or duodenojejunosomy depending on whether a classic or pylorus preserving Whipple is performed. This anastomosis is made approximately 15 cm distal to the hepaticojejunostomy. An end-to-side duodenojejunosomy is performed in two layers; an interrupted layer of 3-0 silk for the outer layers with typically an inner running layer of 3-0 synthetic absorbable suture (Fig. 100.4). For a classic Whipple, a gastrojejunostomy is performed in a similar fashion. Retrocolic versus antecolic reconstruction remains controversial. Retrocolic reconstruction is performed with a proximal portion of jejunum without traversing the mesocolon, while an antecolic anastomosis is performed with a more distal portion of the jejunum “over” the transverse mesocolon. Some groups prefer antecolic reconstruction arguing that venous congestion and bowel edema are increased with a retrocolic technique, thereby leading to increased complications, such as DGE. Others argue that antecolic reconstruction lends itself to increased angulation of the stomach and higher rates of DGE. In addition, some argue that an antecolic anastomosis is less likely to obstruct in the event of a locoregional recurrence. However, multiple randomized controlled trials and metaanalyses have failed to demonstrate a significant difference in postoperative outcomes between a retrocolic versus antecolic reconstruction.<sup>23–27</sup>



**FIGURE 100.4** Final anatomy after pylorus-preserving pancreaticoduodenectomy. Notice the efferent limb of the duodenojejunosomy secured to the transverse mesocolon. (From Kennedy EP, Brumbaugh J, Yeo CJ. Reconstruction following the pylorus preserving Whipple resection: PJ, HJ, and DJ. *J Gastrointest Surg.* 2010;14:408–415.)

The use of drains after pancreaticoduodenectomy has been extensively studied.<sup>28–31</sup> Some groups prefer to abstain from drains at the time of operation and use interventional radiology to drain any postoperative fluid collections that are clinically relevant. Based on data from a multiinstitutional randomized controlled trial, van Buren et al. reported that the avoidance of drains at the time of a Whipple procedure was associated with an increased frequency and severity of complications.<sup>29</sup> Patients without routine drainage were more likely to have a higher average complication severity, longer length of hospital stay, and increased mortality rates. In fact, the study was stopped early by the Data Safety Monitoring Board. We typically place two closed suction drains by the pancreatic and biliary anastomosis with special attention made to prevent the drains from coming into direct contact with the hepatico- and pancreaticojejunostomy.

### Postoperative Care

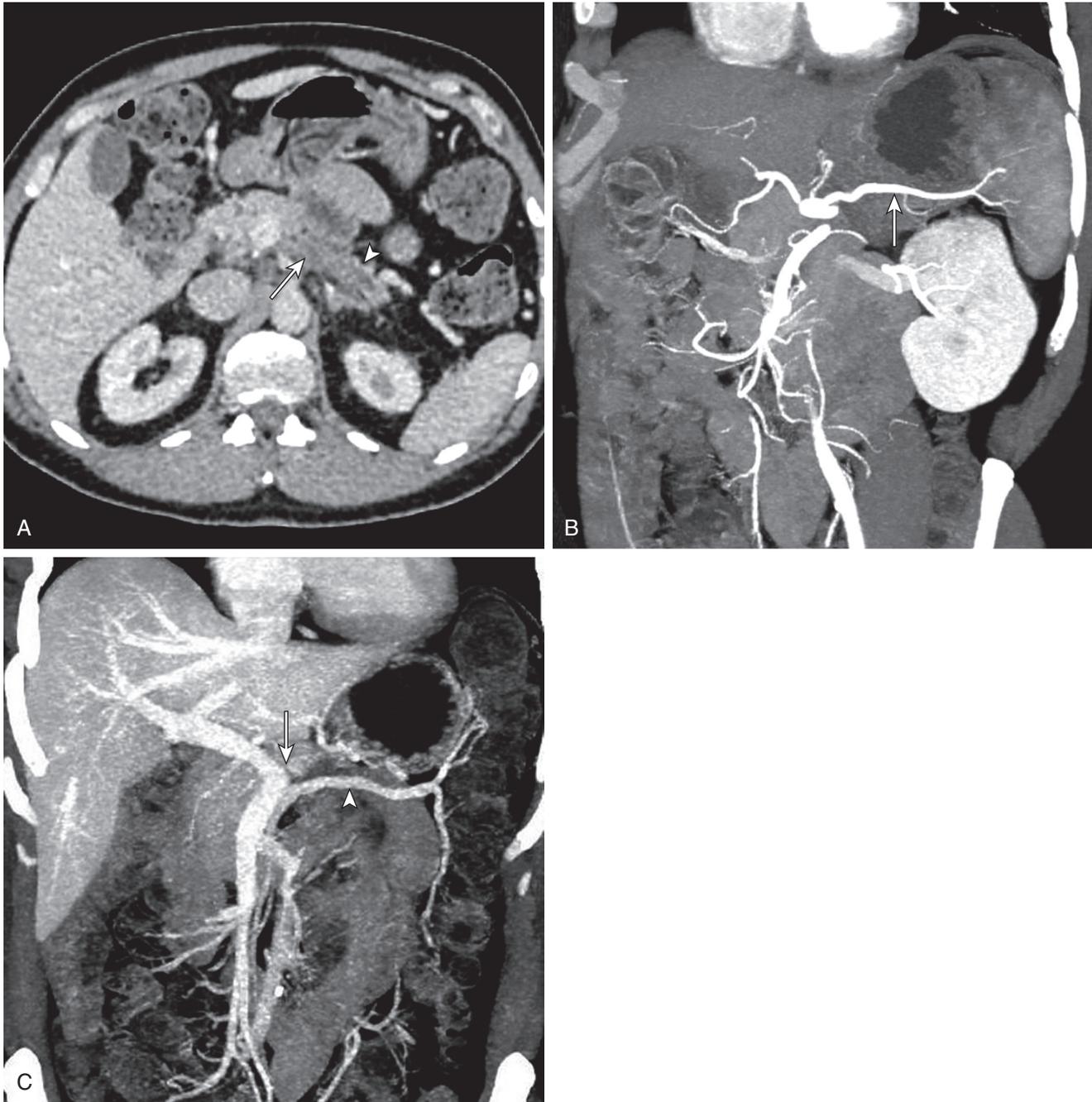
Routine prolonged nasogastric decompression appears unnecessary.<sup>32,33</sup> As such, the nasogastric tube is removed the next morning. The patient has nothing by mouth except “sips and chips” for the first 1 to 2 postoperative days, and then the diet is advanced daily. With regard to drain management, a prospectively validated study from the Massachusetts General Hospital identified a less than 1% risk of pancreatic fistula if postoperative day (POD) 1 drain amylase levels are lower than 600 U/L and recommend early drain removal in these patients.<sup>34</sup> In instances

of high POD 1 drain amylase levels, we prefer to maintain drains in place until the patient is tolerating a regular diet, at which point the drains are removed when low amylase and drain output are low (<20 mL/day).

### DISTAL PANCREATECTOMY FOR CANCERS OF THE BODY OR TAIL

Cancer of the body or tail accounts for nearly one-third of pancreatic adenocarcinomas (Fig. 100.5). Symptoms

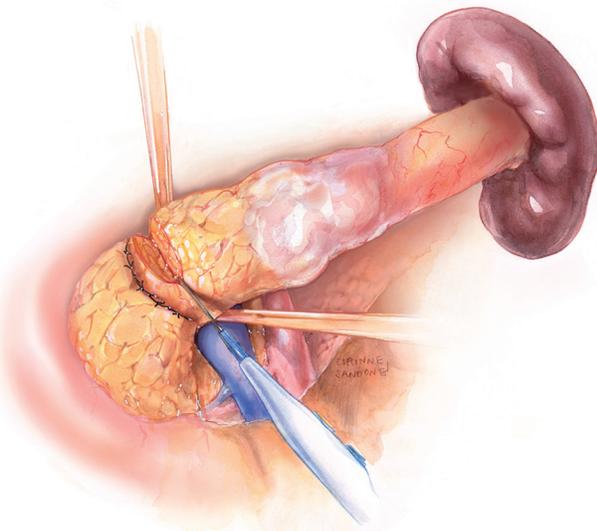
typically manifest late in the course of the disease and therefore are more likely to present with advanced disease. Accordingly, staging laparoscopy is commonly used for these lesions. In the absence of metastases, distal pancreatectomy is the procedure of choice for these tumors. A “bump” may be placed underneath the patient’s left upper back to further elevate the left upper quadrant. A vertical midline incision is typically used, although a bilateral subcostal incision is also acceptable.



**FIGURE 100.5** A 58-year-old male with history of adenocarcinoma in the tail of the pancreas. (A) Axial computed tomography image of the abdomen obtained in the venous phase reveals a subtle mass in the tail of the pancreas (*arrow*), resulting in atrophy of the pancreatic tail and upstream dilatation of the pancreatic duct (*arrowhead*). (B) Coronal maximum intensity projection image in the arterial phase reveals patent splenic artery (*arrow*). (C) Coronal maximum intensity projection image in the venous phase reveals complete occlusion of the splenic vein at the confluence (*arrow*). The splenic artery (*arrowhead*) is not invaded or encased. (Courtesy Ihab Kamel, MD, and Mounes Ghasebeh, MD, Department of Radiology, The Johns Hopkins University School of Medicine.)

The procedure begins with entering the lesser sac by elevating the greater omentum off the transverse colon. The splenic flexure of the colon is mobilized and reflected inferiorly by dividing the splenocolic ligament. The short gastrics are subsequently divided using an electronic sealing device or serial clamp and ties. The spleen is mobilized laterally to medially out of the retroperitoneum by dividing the splenorenal ligament, thereby mobilizing the pancreas out of the retroperitoneum as well. Isolation of the splenic artery and vein may be performed by developing a tunnel behind the pancreatic body and tail. The splenic vein is located posterior to the pancreas often within the pancreatic parenchyma as it courses toward to the spleen; the splenic artery courses along the superior border of the pancreas. The splenic artery should be test clamped and flow in the common hepatic artery confirmed prior to ligating the splenic artery. The splenic artery and vein can be suture ligated or stapled using a vascular load on a linear stapler.

Postoperative pancreatic fistula is the most common complication after distal pancreatectomy. Numerous methods of pancreatic transection and management of the pancreatic remnant have been reported, including using linear stapling devices across the pancreas, direct duct ligation, fibrin glue application, and enteric drainage.<sup>35</sup> No specific method has been demonstrated to be superior. Prior to dividing the pancreas, four stay sutures may be placed along the inferior and superior border of the pancreatic transection line. We prefer to divide the pancreas with electrocautery (Fig. 100.6). The neck of the pancreas is oversewn with overlapping “U”



**FIGURE 100.6** Transection of pancreatic neck during distal pancreatectomy. A Penrose drain has been placed across the underside of the pancreatic neck, anterior to the portal vein–superior mesenteric vein confluence to aid in elevating the pancreatic neck during transection. (Image drawn by Corinne Sandone, MA, CMI. From Cameron JL, Sandone C. *Atlas of Gastrointestinal Surgery*. Vol 1. 2nd ed. Shelton, CT: People’s Medical Publishing House; 2014:315. Used with permission from PMPH-USA, LTD, Shelton, CT.)

stitches, and the duct is directly ligated when it can be identified. One or two 19-French drains are placed in the left upper quadrant and along the edge of the pancreatic remnant.

Postoperative management is relatively straightforward. Diets are advanced as tolerated. The drain output is monitored for evidence of pancreatic leak, and drain amylase levels are measured as indicated. Postsplenectomy vaccines for *Neisseria meningitidis*, *Streptococcus pneumoniae*, and *Haemophilus influenzae* are given preoperatively or on the day of discharge.

### Splenic Preservation

Mallet-Guy and Vachon first described a spleen-preserving distal pancreatectomy in 1943.<sup>36,37</sup> Classically, however, splenic preservation is contraindicated in cases where malignancy is suspected given the close proximity of the splenic blood supply to the pancreas and the potential to negatively impact oncologic resection. Some reports demonstrate fewer postoperative complications and improved survival with spleen-preserving distal pancreatectomy compared with distal pancreatectomy and splenectomy.<sup>36,38</sup> In cases of pancreatic adenocarcinoma in the body or tail of the pancreas, we typically prefer resection of the distal pancreas and spleen en bloc. Splenic preservation is more appropriate in cases of benign disease or tumors with low malignant potential.

Splenic preservation can be performed by either preserving the splenic vessels or the Warshaw technique,<sup>39</sup> in which the splenic vessels are ligated but the short gastric are preserved. Outcomes appear similar with both approaches; however, splenic infarcts and secondary splenectomies occur more frequently with the Warshaw technique.<sup>36</sup> In cases of splenic preservation we prefer to preserve the splenic vessels whenever possible. This requires mobilizing the pancreatic tail and careful dissection of the various pancreatic branches from the splenic artery and vein from proximal to distal on the pancreas. The spleen is not mobilized medially to avoid inadvertent injury.

### Appleby Procedure

The Appleby procedure was first described in 1953 and includes en bloc resection of the celiac axis, distal pancreatectomy with splenectomy, and total gastrectomy.<sup>40</sup> It was originally intended for locally advanced gastric cancer; however, in 1976 Nimura reported the first Appleby for locally advanced pancreatic adenocarcinoma of the body and tail.<sup>41</sup> With improvements in neoadjuvant pancreatic cancer chemoradiotherapy, an increasing number of patients are presenting with local tumor progression without evidence of metastatic disease. The Appleby procedure has been slow to gain popularity; however, there are an increasing number of series in the literature reporting either the Appleby or modified Appleby procedure for locally advanced pancreatic adenocarcinoma. The modified Appleby includes distal pancreatectomy, splenectomy, combined with celiac axis resection with resection of the common hepatic artery proximal to the GDA without gastrectomy.<sup>42</sup> The arterial blood supply to the liver is subsequently dependent on the pancreaticoduodenal branches from the superior mesenteric artery

supplying the GDA. In select cases, arterial reconstruction, most often common hepatic artery to aorta, may be used.<sup>42</sup>

Outcomes of the modified Appleby for locally advanced pancreatic adenocarcinoma have not been clearly defined.<sup>42–44</sup> In a multicenter series derived from the American College of Surgeons National Surgical Quality Improvement Program (NSQIP) Pancreatectomy Demonstration Project that compared standard distal pancreatectomy versus distal pancreatectomy and concurrent celiac axis resection, patients who underwent celiac axis resection had a longer operative time, higher postoperative acute kidney injury, and a 10% operative mortality.<sup>45</sup> Although the modified Appleby procedure may be indicated in certain locally advanced body and tail tumors of the pancreas, these patients are most likely at increased risk of postoperative complications and death; as such, prudent and appropriate patient selection is critical.

### TOTAL PANCREATECTOMY

Given the poor overall survival associated with pancreatic cancer, total pancreatectomy was proposed as a more radical approach in the 1960s and 1970s. A more radical resection was thought to potentially improve outcomes by completely removing all of the gland at risk, as well as decreasing morbidity and mortality due to the lack of a pancreaticoenteric anastomosis. Outcomes following total pancreatectomy were initially poor with increased postoperative morbidity and no improvement in long-term disease-free or overall survival. More recently, with improved operative technique and better perioperative care, outcomes following total pancreatectomies have improved and the number of total pancreatectomies for pancreatic cancer has increased.<sup>46</sup> Total pancreatectomy leaves the patient with difficult to manage brittle diabetes and persistent diarrhea and steatorrhea secondary to the loss of exocrine function. However, modern day, long-acting insulin analogues and pancreatic enzyme supplementation have improved the management of these problems. In fact, modern-day surgical series report acceptable long-term quality of life.<sup>47–49</sup> Morbidity and mortality associated with total pancreatectomy has decreased dramatically over time, although perioperative morbidity and mortality rates remain higher among patients undergoing total pancreatectomy versus pancreaticoduodenectomy, particularly when combined with vascular resections.<sup>46,47,50,51</sup> Despite this, long-term survival is equivalent in most modern series when comparing total pancreatectomy and pancreaticoduodenectomy.<sup>46,47,51,52</sup> As such, total pancreatectomy should be considered when required to achieve a margin-negative resection. Typically, the head or tail has been mobilized, and a total pancreatectomy becomes necessary due to a persistently positive margin. The technique for total pancreatectomy in pancreatic cancer therefore consists of mobilization of the remnant pancreas. In cases in which the pancreatic head has been resected, the remnant pancreas should then be excised along with the spleen. The short gastric vessels are ligated and divided. The splenic artery is taken at its origin, while the splenic vein is divided at the PV/SMV confluence. The remnant pancreas and spleen are then mobilized in a medial to lateral fashion.

### MULTIVISCERAL RESECTION

The benefits of extended resections in pancreatic cancer have been debated and extensively studied. One indication for multivisceral resection in pancreatic cancer is an advanced tumor invading the hepatic flexure or transverse colon requiring a hemicolectomy.<sup>53,54</sup> Retrospective series comparing standard pancreatic resections versus resections that include an additional visceral resection demonstrate increased morbidity and mortality in the latter group.<sup>54–56</sup> In an NSQIP database analysis, perioperative mortality and morbidity rate with multivisceral resection at the time of pancreaticoduodenectomy was 8.8% and 56.8%, respectively, versus 2.9% and 30.8% for a standard pancreaticoduodenectomy.<sup>54</sup> In multivariate analysis, multivisceral resection was an independent predictor of increased perioperative mortality and morbidity.

The benefit of multivisceral resection in pancreatic cancer is to obtain a curative resection with negative margins. Patients requiring multivisceral resection generally present with larger, more locally advanced tumors needing extended resection for contiguous organ involvement.<sup>57</sup> Despite this, retrospective series analyzing long-term outcomes of pancreatic cancer patients who undergo a multivisceral resection have a comparable 3-year and 5-year overall survival versus a standard pancreatic resection.<sup>56–59</sup> More importantly, overall survival in pancreatic cancer patients with multivisceral resection is significantly improved compared with patients who have unresected pancreatic cancer.<sup>59</sup> As such, multivisceral resections in pancreatic cancer should be attempted when a curative R0 resection can be achieved. Appropriate patient selection and performance by an experienced surgeon in specialized pancreatic cancer centers are important.

### MINIMALLY INVASIVE PANCREATIC SURGERY

Further advancements in the field of pancreatic surgery have led to the introduction of both laparoscopic and robotic pancreatic resections. Both techniques have demonstrated acceptable early outcomes and likely equivalent oncologic outcomes compared with open resection, particularly in the hands of experienced pancreatic surgeons. Potential advantages include decreased wound complications and postoperative pain, as well as shortened length of stay. Most of the perceived benefits are derived from retrospective series because no randomized controlled trials have been performed.

More recently, robotic pancreatic resections have increased in popularity. Early results with regard to complications and oncologic outcomes are similar for both distal pancreatectomies and pancreaticoduodenectomies; however, there are no randomized control trials that compare robotic resection with traditional open or laparoscopic approaches.<sup>60–63</sup> Ultimately, outcomes appear similar with either minimally invasive approach, and the optimal technique depends mainly on surgeon comfort (see Chapter 101 for a more detailed discussion of this topic).

#### Laparoscopic Distal Pancreatectomy

Distal pancreatectomy was one of the first pancreatic procedures to be attempted using a minimal invasive

approach. Laparoscopic distal pancreatectomy has gained widespread acceptance in the treatment of benign pancreatic disease. More recently, numerous series have reported on the use of laparoscopic distal pancreatectomy for pancreatic ductal adenocarcinoma and noted equivalent oncologic outcomes, fewer complications, and shorter length of stay compared with open distal pancreatectomy.<sup>64-69</sup> For example, in a series of 2753 pancreatectomies, the French Pancreatectomy Study Group demonstrated largely comparable outcomes for laparoscopic distal pancreatectomy versus open distal pancreatectomy, with lower postoperative morbidity and shorter length of stay in the laparoscopic group.<sup>64</sup>

Laparoscopic distal pancreatectomy begins with insertion of an infraumbilical port and establishment of pneumoperitoneum via either Veress needle or Hassan cutdown technique. Three more ports are typically used, one in the left lower quadrant and two additional ports along the upper midline. The dissection begins with taking down the gastrocolic ligament and short gastric vessels using an electronic dissector. The splenic flexure of the colon is mobilized and taken down. The pancreas is mobilized by incising the peritoneum overlying its inferior border, and dissection continues until the splenic vessels are visualized. The pancreatic tail can be suspended by an instrument to allow better visualization of the splenic vessels. The splenic artery is confirmed by tracing it proximally to the celiac axis if necessary. Both the splenic artery and vein are ligated using a linear stapler with a vascular (white) load. The pancreas is divided with an Endo GIA stapler. The spleen is then mobilized from its retroperitoneal attachments, and the specimen is delivered via an Endo Catch bag. The pancreatic neck margin is sent for frozen-section analysis.

### Laparoscopic Pancreaticoduodenectomy

The first laparoscopic pancreaticoduodenectomy was reported by Gagner and Pomp in 1994.<sup>70</sup> Since then, the use of minimally invasive pancreaticoduodenectomy (MIPD) has been slowly growing as a result of improved technology and more experience among pancreatic surgeons. As such, laparoscopic pancreaticoduodenectomies are currently performed in centers throughout the world. The data comparing MIPDs are variable, given that minimally invasive Whipple procedures include both laparoscopic and robotic approaches. Zhang et al.<sup>71</sup> performed a systematic review comparing MIPD versus the open approach. They included 1018 MIPDs compared with 5102 open pancreaticoduodenectomies. Despite longer operative times, MIPD Whipple procedures were associated with less blood loss, lower wound infections, and a 3.5-day shorter length of stay.<sup>71</sup> Although outcomes following MIPD appear comparable with open resections for pancreatic cancer, well-designed randomized controlled trials with extensive follow-up are lacking.<sup>62,72,73</sup>

Although a more detailed explanation can be found in the chapter on [minimally invasive pancreatic surgery](#), in brief, six 10-mm ports are positioned in a semicircle around the umbilicus extending from the left upper quadrant to the right upper quadrant.<sup>72</sup> The hepatic artery is identified, and the GDA is then confirmed and ligated. The antrum is retracted, and the first portion of the

duodenum is divided. The inferior border of the pancreas is dissected to identify the SMV. A tunnel underneath the neck of the pancreas is created, and an umbilical tape is placed around the pancreas for retraction. The gallbladder is mobilized, and the common bile duct is encircled and subsequently divided. A wide Kocher maneuver is performed, and the jejunum is divided with a stapler 10 cm from the ligament of Treitz. Finally, the pancreatic neck is transected using an energy device, and the uncinata is then taken off of the superior mesenteric artery in a similar fashion. Of note, the pancreaticoduodenal branches will need to be divided between clips.

The jejunum is brought into the right upper quadrant through the ligament of Treitz defect. Reconstruction is performed in a similar fashion to the open technique, consisting of an end-to-side, duct to mucosa, 1- or 2-layer pancreaticojejunostomy, a single layer end-to-side hepaticojejunostomy, and an end-to-side, antecolic duodenojejunostomy. This final anastomosis is generally stapled, although a sewn 2-layer anastomosis is acceptable.

### COMPLICATIONS AFTER PANCREATIC RESECTION

Although the mortality incidence in high-volume pancreatic surgery centers is only 2% to 3%, morbidity remains high, ranging from 30% to 50%.<sup>74</sup> The most common complications after pancreaticoduodenectomy includes DGE (7% to 21%), pancreatic fistula (7% to 15%), and wound infections (8% to 14%) (Table 100.1).<sup>9,74</sup> Older patients (>80 years old) and patients with increased comorbidities are more likely to die during their hospitalization.<sup>9</sup> Distal pancreatectomy for pancreatic adenocarcinoma has a similar mortality (1%) and morbidity (30%).<sup>69</sup> Pancreatic fistula and wound infections are the most common complications.

DGE is generally self-limited and non-life-threatening but may lead to a prolonged length of stay and increased hospital costs.<sup>75</sup> Treatment involves nasogastric decompression and sometimes parenteral nutrition support when the patient has a prolonged DGE course. In severe cases a gastrostomy tube may even be necessary; however, this is rare. The management of a postoperative pancreatic fistula varies from no interventions to the need for reoperation. Pancreatic fistula accounts for a significant proportion of early postoperative deaths after pancreatectomy

**TABLE 100.1** Morbidity After Pancreaticoduodenectomy

Complication	n	%
Delayed gastric emptying	410	21
Postoperative pancreatic fistula	295	15
Wound infection	222	11
Cardiac event	69	3
Pneumonia	38	2
Delayed bleeding	32	2
Chyle leak	28	1
Any complication	894	45

From Cameron JL, He J. Two thousand consecutive pancreaticoduodenectomies. *J Am Coll Surg*. 2015;220:530-536.

secondary to sepsis/multisystem organ failure and bleeding secondary to pseudoaneurysms. If intraoperative drains are in place, amylase levels may be checked to confirm a pancreatic leak. When cross-sectional imaging demonstrates an intraabdominal abscess, percutaneous drainage via interventional radiology techniques is appropriate. If the patient is otherwise well with no evidence of infection, tolerating a regular diet with a seemingly well-controlled leak, conservative management with outpatient drain management is appropriate.

Despite numerous clinical trials, the use of octreotide has not been shown to be effective in preventing postoperative pancreatic fistulas or associated complications. More recently, a single-center, randomized double blind trial examined 300 patients undergoing either pancreaticoduodenectomy or distal pancreatectomy who received either 900 µg subcutaneous pasireotide or placebo.<sup>76</sup> Of these patients, 15% reached the primary end point, which was grade 3 or higher postoperative pancreatic fistula, leak, or abscess. The pasireotide group demonstrated a significantly decreased risk of postoperative pancreatic fistula compared with the placebo group (9% vs. 21%;  $P = .006$ ). The beneficial effect of pasireotide was noted in both the pancreaticoduodenectomy and distal pancreatectomy cohorts.

Delayed bleeding is one of the most severe postoperative complications after a pancreatectomy. The International Study Group of Pancreatic Surgery developed a consensus definition in 2007 that defined criteria for postpancreatectomy hemorrhage based on clinical factors assessing the severity of bleeding.<sup>77</sup> Fortunately, postpancreatectomy hemorrhage is rare, with an incidence of 1.5%; however, the mortality can be as high as 30% to 40%.<sup>9,78</sup> Postpancreatectomy hemorrhage is most often secondary to a pseudoaneurysm in the presence of a pancreaticojejunostomy leak, although gastrojejunostomy/duodenojejunostomy anastomotic bleeding can also occur. Management preferably consists of interventional radiology techniques to embolize the false aneurysm/gastroduodenal stump. When embolization of the gastroduodenal stump is not feasible, a covered stent across the common/proper hepatic artery that excludes the false aneurysm should be considered. When bleeding is secondary to an intraluminal/enteric anastomotic source, endoscopic techniques can be used. In instances of hemodynamic instability, immediate reexploration is warranted.

## CONCLUSION

Surgery remains the only chance of long-term survival for patients with pancreas adenocarcinoma. Although mortality from pancreatic resections has decreased significantly, morbidity remains high. More aggressive surgical approaches, including vascular resection and multivisceral resection, have demonstrated acceptable outcomes and have allowed for an increased number of patients to be considered for surgery. However, proper patient selection, a multidisciplinary approach, and referral to high-volume centers are required to ensure optimal outcomes. Although technical excellence is critical, pancreatic surgeons need to play a role in identifying more effective adjuvant therapy

for this disease if we are to optimize outcomes for our patients.

## REFERENCES

1. Witzel O. Beiträge zur Chirurgie der Bauchorgane. *Dtsch Zeitschr Chir.* 1886;24:326-354.
2. Schnelldorfer T, Adams DB, Warshaw AL, Lillemoe KD, Sarr MG. Forgotten pioneers of pancreatic surgery: beyond the favorite few. *Ann Surg.* 2008;247:191-202.
3. Halsted WS. Contributions to the surgery of the bile passages, especially of the common bile-duct. *Boston Med Surg J.* 1899;141:645-654.
4. Sauve L. Des pancreatectomies et spécialement de la pancréatectomie céphalique. *Rev Chir.* 1908;37:113-152, 335-385.
5. Kausch W. Das Carcinom der Paipilla duodeni und seine radikale Entfernung. *Beitr Klin Chir.* 1912;78:439-486.
6. Hirschel G. Die Resektion des Duodenums mit der Papille wegen Karzinoms. *München Med Wochenschr.* 1914;61:1728-1729.
7. Whipple AO, Parsons WB, Mullins CR. Treatment of carcinoma of the ampulla of Vater. *Ann Surg.* 1935;102:763-779.
8. Whipple AO. Pancreaticoduodenectomy for islet carcinoma: a five-year follow-up. *Ann Surg.* 1945;121:847-852.
9. Cameron JL, He J. Two thousand consecutive pancreaticoduodenectomies. *J Am Coll Surg.* 2015;220:530-536.
10. Sohn TA, Yeo CJ, Cameron JL, Pitt HA, Lillemoe KD. Do preoperative biliary stents increase postpancreaticoduodenectomy complications? *J Gastrointest Surg.* 2000;24:258-267 [discussion 267-258].
11. Povoski SP, Karpeh MS Jr, Conlon KC, Blumgart LH, Brennan MF. Association of preoperative biliary drainage with postoperative outcome following pancreaticoduodenectomy. *Ann Surg.* 1999;230:131-142.
12. Alamo JM, Marin LM, Suarez G, et al. Improving outcomes in pancreatic cancer: key points in perioperative management. *World J Gastroenterol.* 2014;20:14237-14245.
13. Conlon KC, Dougherty E, Klimstra DS, Coit DG, Turnbull AD, Brennan MF. The value of minimal access surgery in the staging of patients with potentially resectable peripancreatic malignancy. *Ann Surg.* 1996;223:134-140.
14. Vollmer CM, Drebin JA, Middleton WD, et al. Utility of staging laparoscopy in subsets of peripancreatic and biliary malignancies. *Ann Surg.* 2002;235:1-7.
15. Allen VB, Gurusamy KS, Takwoingi Y, Kalia A, Davidson BR. Diagnostic accuracy of laparoscopy following computed tomography (CT) scanning for assessing the resectability with curative intent in pancreatic and periampullary cancer. *Cochrane Database Syst Rev.* 2013;(11):CD009323.
16. Hüttner FJ, Fitzmaurice C, Schwarzer G, et al. Pylorus-preserving pancreaticoduodenectomy (pp Whipple) versus pancreaticoduodenectomy (classic Whipple) for surgical treatment of periampullary and pancreatic carcinoma. *Cochrane Database Syst Rev.* 2016;(2):CD006053.
17. Wu W, Hong X, Fu L, et al. The effect of pylorus removal on delayed gastric emptying after pancreaticoduodenectomy: a meta-analysis of 2,599 patients. *PLoS One.* 2014;9:e108380.
18. Fortner JG. Regional resection of cancer of the pancreas: a new surgical approach. *Surgery.* 1973;73:307-320.
19. Christians KK, Pilgrim CH, Tsai S, et al. Arterial resection at the time of pancreatectomy for cancer. *Surgery.* 2014;155:919-926.
20. Menaheem B, Guittet L, Mulliri A, Alves A, Lubrano J. Pancreaticogastrostomy is superior to pancreaticojejunostomy for prevention of pancreatic fistula after pancreaticoduodenectomy: an updated meta-analysis of randomized controlled trials. *Ann Surg.* 2015;261:882-887.
21. Wellner UF, Sick O, Olschewski M, Adam U, Hopt UT, Keck T. Randomized controlled single-center trial comparing pancreaticogastrostomy versus pancreaticojejunostomy after partial pancreaticoduodenectomy. *J Gastrointest Surg.* 2012;16:1686-1695.
22. Crippa S, Cirocchi R, Randolph J, et al. Pancreaticogastrostomy is comparable to pancreaticogastrostomy after pancreaticoduodenectomy: an updated meta-analysis of randomized controlled trials. *Langenbecks Arch Surg.* 2016;401:427-437.
23. Joliat GR, Labgaa I, Demartines N, Schäfer M, Allemann P. Effect of antecolic versus retrocolic gastroenteric reconstruction after pancreaticoduodenectomy on delayed gastric emptying: a meta-analysis of six randomized controlled trials. *Dig Surg.* 2016;33:15-25.

24. Gangavattiker R, Pal S, Javed A, Dash NR, Sahni P, Chattopadhyay TK. Effect of antecolic or retrocolic reconstruction of the gastro/duodenojejunostomy on delayed gastric emptying after pancreaticoduodenectomy: a randomized controlled trial. *J Gastrointest Surg.* 2011;15:843-852.
25. Eshuis WJ, van Eijck CH, Gerhards MF, et al. Antecolic versus retrocolic route of the gastroenteric anastomosis after pancreaticoduodenectomy: a randomized controlled trial. *Ann Surg.* 2014;259:45-51.
26. Bell R, Pandanaboyana S, Shah N, Bartlett A, Windsor JA, Smith AM. Meta-analysis of antecolic versus retrocolic gastric reconstruction after a pylorus-preserving pancreaticoduodenectomy. *HPB (Oxford).* 2015;17:202-208.
27. Tamandl D, Sahara K, Prucker J, et al. Impact of the reconstruction method on delayed gastric emptying after pylorus-preserving pancreaticoduodenectomy: a prospective randomized study. *World J Surg.* 2014;38:465-475.
28. McMillan MT, Malleo G, Bassi C, et al. Drain management after pancreaticoduodenectomy: reappraisal of a prospective randomized trial using risk stratification. *J Am Coll Surg.* 2015;221:798-809.
29. Van Buren G 2nd, Bloomston M, Hughes SJ, et al. A randomized prospective multicenter trial of pancreaticoduodenectomy with and without routine intraperitoneal drainage. *Ann Surg.* 2014;259:605-612.
30. Correa-Gallego C, Brennan MF, D'Angelica M, et al. Operative drainage following pancreatic resection: analysis of 1122 patients resected over 5 years at a single institution. *Ann Surg.* 2013;258:1051-1058.
31. Conlon KC, Labow D, Leung D, et al. Prospective randomized clinical trial of the value of intraperitoneal drainage after pancreatic resection. *Ann Surg.* 2001;234:487-493 [discussion 493-484].
32. Kunstman JW, Klemen ND, Fonseca AL, Araya DL, Salem RR. Nasogastric drainage may be unnecessary after pancreaticoduodenectomy: a comparison of routine vs selective decompression. *J Am Coll Surg.* 2013;217:481-488.
33. Fisher WE, Hodges SE, Cruz G, et al. Routine nasogastric suction may be unnecessary after a pancreatic resection. *HPB (Oxford).* 2011;13:792-796.
34. Ven Fong Z, Correa-Gallego C, Ferrone CR, et al. Early drain removal—the middle ground between the drain versus no drain debate in patients undergoing pancreaticoduodenectomy: a prospective validation study. *Ann Surg.* 2015;262:378-383.
35. Diener MK, Seiler CM, Rossion I, et al. Efficacy of stapler versus hand-sewn closure after distal pancreatectomy (DISPACT): a randomised, controlled multicentre trial. *Lancet.* 2011;377:1514-1522.
36. Shi N, Liu SL, Li YT, You L, Dai MH, Zhao YP. Splenic preservation versus splenectomy during distal pancreatectomy: a systematic review and meta-analysis. *Ann Surg Oncol.* 2016;23:365-374.
37. Mallet-Guy P, Vachon A. *Pancreatitis Chroniques Gauches.* Paris: Masson & Cie; 1943.
38. Schwarz RE, Harrison LE, Conlon KC, Klimstra DS, Brennan MF. The impact of splenectomy on outcomes after resection of pancreatic adenocarcinoma. *J Am Coll Surg.* 1999;188:516-521.
39. Warshaw AL. Conservation of the spleen with distal pancreatectomy. *Arch Surg.* 1988;123:550-553.
40. Appleby LH. The coeliac axis in the expansion of the operation for gastric carcinoma. *Cancer.* 1953;6:704-707.
41. Nimura Y, Hattori T, Miura K, et al. Resection of advanced pancreatic body-tail carcinoma by Appleby's operation. *Shujutu.* 1976;30:885-889.
42. Latona JA, Lamb KM, Pucci MJ, Maley WR, Yeo CJ. Modified Appleby procedure with arterial reconstruction for locally advanced pancreatic adenocarcinoma: a literature review and report of three unusual cases. *J Gastrointest Surg.* 2016;20:300-306.
43. Wu X, Tao R, Lei R, et al. Distal pancreatectomy combined with celiac axis resection in treatment of carcinoma of the body/tail of the pancreas: a single-center experience. *Ann Surg Oncol.* 2010;17:1359-1366.
44. Jing W, Zhu G, Hu X, et al. Distal pancreatectomy with en bloc celiac axis resection for the treatment of locally advanced pancreatic body and tail cancer. *Hepatogastroenterology.* 2013;60:187-190.
45. Beane JD, House MG, Pitt SC, et al. Distal pancreatectomy with celiac axis resection: what are the added risks? *HPB (Oxford).* 2015;17:777-784.
46. Reddy S, Wolfgang CL, Cameron JL, et al. Total pancreatectomy for pancreatic adenocarcinoma: evaluation of morbidity and long-term survival. *Ann Surg.* 2009;250:282-287.
47. Hartwig W, Gluth A, Hinz U, et al. Total pancreatectomy for primary pancreatic neoplasms: renaissance of an unpopular operation. *Ann Surg.* 2015;261:537-546.
48. Muller MW, Friess H, Kleeff J, et al. Is there still a role for total pancreatectomy? *Ann Surg.* 2007;246:966-974 [discussion 974-965].
49. Belyaev O, Herzog T, Chromik AM, Meurer K, Uhl W. Early and late postoperative changes in the quality of life after pancreatic surgery. *Langenbecks Arch Surg.* 2013;398:547-555.
50. Bhayani NH, Miller JL, Ortenzi G, et al. Perioperative outcomes of pancreaticoduodenectomy compared to total pancreatectomy for neoplasia. *J Gastrointest Surg.* 2014;18:549-554.
51. Johnston WC, Hoen HM, Cassera MA, et al. Total pancreatectomy for pancreatic ductal adenocarcinoma: review of the National Cancer Data Base. *HPB (Oxford).* 2016;18:21-28.
52. Satoi S, Murakami Y, Motoi F, et al. Reappraisal of total pancreatectomy in 45 patients with pancreatic ductal adenocarcinoma in the modern era using matched-pairs analysis: Multicenter Study Group of Pancreatobiliary Surgery in Japan. *Pancreas.* 2016;45:1003-1009.
53. Nikfarjam M, Sehmbe M, Kimchi ET, et al. Additional organ resection combined with pancreaticoduodenectomy does not increase postoperative morbidity and mortality. *J Gastrointest Surg.* 2009;13:915-921.
54. Bhayani NH, Enomoto LM, James BC, et al. Multivisceral and extended resections during pancreaticoduodenectomy increase morbidity and mortality. *Surgery.* 2014;155:567-574.
55. Kleeff J, Diener MK, Z'Graggen K, et al. Distal pancreatectomy: risk factors for surgical failure in 302 consecutive cases. *Ann Surg.* 2007;245:573-582.
56. Kulemann B, Hoepfner J, Wittel U, et al. Perioperative and long-term outcome after standard pancreaticoduodenectomy, additional portal vein and multivisceral resection for pancreatic head cancer. *J Gastrointest Surg.* 2015;19:438-444.
57. Hartwig W, Hackert T, Hinz U, et al. Multivisceral resection for pancreatic malignancies: risk-analysis and long-term outcome. *Ann Surg.* 2009;250:81-87.
58. Sasson AR, Hoffman JP, Ross EA, et al. En bloc resection for locally advanced cancer of the pancreas: is it worthwhile? *J Gastrointest Surg.* 2002;6:147-157 [discussion 157-148].
59. Burdelski CM, Reeh M, Bogoevski D, et al. Multivisceral resections in pancreatic cancer: identification of risk factors. *World J Surg.* 2011;35:2756-2763.
60. Huang B, Feng L, Zhao J. Systematic review and meta-analysis of robotic versus laparoscopic distal pancreatectomy for benign and malignant pancreatic lesions. *Surg Endosc.* 2016;30:4078-4085.
61. Lai EC, Yang GP, Tang CN. Robot-assisted laparoscopic pancreaticoduodenectomy versus open pancreaticoduodenectomy—a comparative study. *Int J Surg.* 2012;10:475-479.
62. Zureikat AH, Breaux JA, Steel JL, Hughes SJ. Can laparoscopic pancreaticoduodenectomy be safely implemented? *J Gastrointest Surg.* 2011;15:1151-1157.
63. Sharpe SM, Talamonti MS, Wang CE, et al. Early national experience with laparoscopic pancreaticoduodenectomy for ductal adenocarcinoma: a comparison of laparoscopic pancreaticoduodenectomy and open pancreaticoduodenectomy from the National Cancer Data Base. *J Am Coll Surg.* 2015;221:175-184.
64. Sulpice L, Farges O, Goutte N, et al. Laparoscopic distal pancreatectomy for pancreatic ductal adenocarcinoma: time for a randomized controlled trial? Results of an All-inclusive National Observational Study. *Ann Surg.* 2015;262:868-873 [discussion 873-864].
65. Kooby DA, Hawkins WG, Schmidt CM, et al. A multicenter analysis of distal pancreatectomy for adenocarcinoma: is laparoscopic resection appropriate? *J Am Coll Surg.* 2010;210:779-785, 786-787.
66. DiNordia J, Schrope BA, Lee MK, et al. Laparoscopic distal pancreatectomy offers shorter hospital stays with fewer complications. *J Gastrointest Surg.* 2010;14:1804-1812.
67. Sharpe SM, Talamonti MS, Wang E, et al. The laparoscopic approach to distal pancreatectomy for ductal adenocarcinoma results in shorter lengths of stay without compromising oncologic outcomes. *Am J Surg.* 2015;209:557-563.
68. Stauffer JA, Rosales-Velderrain A, Goldberg RF, Bowers SP, Asbun HJ. Comparison of open with laparoscopic distal pancreatectomy: a single institution's transition over a 7-year period. *HPB (Oxford).* 2013;15:149-155.
69. Riviere D, Gurusamy KS, Kooby DA, et al. Laparoscopic versus open distal pancreatectomy for pancreatic cancer. *Cochrane Database Syst Rev.* 2016;(4):CD011391.

70. Gagner M, Pomp A. Laparoscopic pylorus-preserving pancreaticoduodenectomy. *Surg Endosc*. 1994;8:408-410.
71. Zhang H, Wu X, Zhu F, et al. Systematic review and meta-analysis of minimally invasive versus open approach for pancreaticoduodenectomy. *Surg Endosc*. 2016;[Epub ahead of print].
72. Tee MC, Kendrick ML, Farnell MB. Laparoscopic pancreaticoduodenectomy: is it an effective procedure for pancreatic ductal adenocarcinoma? *Adv Surg*. 2015;49:143-156.
73. Asbun HJ, Stauffer JA. Laparoscopic vs open pancreaticoduodenectomy: overall outcomes and severity of complications using the Accordion Severity Grading System. *J Am Coll Surg*. 2012;215:810-819.
74. He J, Ahuja N, Makary MA, et al. 2564 resected periampullary adenocarcinomas at a single institution: trends over three decades. *HPB (Oxford)*. 2014;16:83-90.
75. Eisenberg JD, Rosato EL, Lavu H, Yeo CJ, Winter JM. Delayed gastric emptying after pancreaticoduodenectomy: an analysis of risk factors and cost. *J Gastrointest Surg*. 2015;19:1572-1580.
76. Allen PJ, Gönen M, Brennan MF, et al. Pasireotide for postoperative pancreatic fistula. *N Engl J Med*. 2014;370:2014-2022.
77. Wente MN, Veit JA, Bassi C, et al. Postpancreatectomy hemorrhage (PPH): an International Study Group of Pancreatic Surgery (ISGPS) definition. *Surgery*. 2007;142:20-25.
78. Grützmann R, Rückert F, Hippe-Davies N, Distler M, Saeger HD. Evaluation of the International Study Group of Pancreatic Surgery definition of post-pancreatectomy hemorrhage in a high-volume center. *Surgery*. 2012;151:612-620.