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**DEFINITION**

- Pancreaticoduodenectomy (Whipple procedure) is defined as resection of the pancreatic head, uncinate process, gallbladder, distal bile duct, duodenum, and gastric antrum.
- Pylorus-preserving pancreaticoduodenectomy (pylorus-preserving Whipple procedure) is the same operation with preservation of the gastric antrum, pylorus, and a cuff of proximal duodenum.
- Complete excision of pancreatic head tumors with negative margins maximizes local-regional control and is the standard of care for malignancies of the pancreatic head, ampulla of Vater, duodenum, or distal bile duct.

**DIFFERENTIAL DIAGNOSIS**

- Pancreatic ductal adenocarcinoma
- Pancreatic neuroendocrine tumor
- Pancreatic cystic neoplasm
- Cancer of the ampulla of Vater
- Distal cholangiocarcinoma
- Duodenal adenocarcinoma
- Biliary stricture
- Chronic pancreatitis

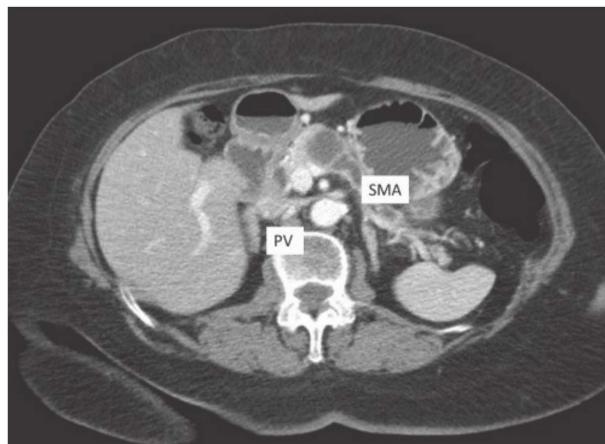
**PATIENT HISTORY AND PHYSICAL FINDINGS**

- A thorough history and physical exam should be performed prior to treatment.
- Critical history: weight loss greater than 10%, new-onset diabetes, jaundice, vague abdominal pain in mid-epigastrum, pain penetrating to the back (indicates possible celiac involvement), diarrhea (indicating exocrine insufficiency)
- History related to biliary obstruction: jaundice, fever, chills, pruritus, acholic stools, dark urine
- Risk factors for pancreatic cancer: smoking, chronic pancreatitis, diabetes, age 65 years or older, African American race, obesity, male gender, family history of pancreatic cancer, family history of other malignancy (i.e., BRCA2 malignancies)<sup>1</sup>
- Physical exam: scleral icterus, jaundice, signs of malnutrition, cachexia, temporal wasting
- Ominous signs: A palpable abdominal tumor or ascites may indicate metastatic disease. Left supraclavicular lymphadenopathy (Virchow's lymph node) is indicative of metastatic disease.
- In addition to a history and physical relating to pancreatic cancer, an overall assessment of the patient's functional status should be performed to assure the patient is a candidate for major surgery.
  - If the patient's performance status is poor (Eastern Conference Oncology Group [ECOG] score greater than 2 or Karnofsky score of less than 60), he or she should be considered physiologically borderline resectable.<sup>2</sup>
  - The patient's cardiopulmonary status should also be assessed with an assessment of their exercise tolerance and activity level.

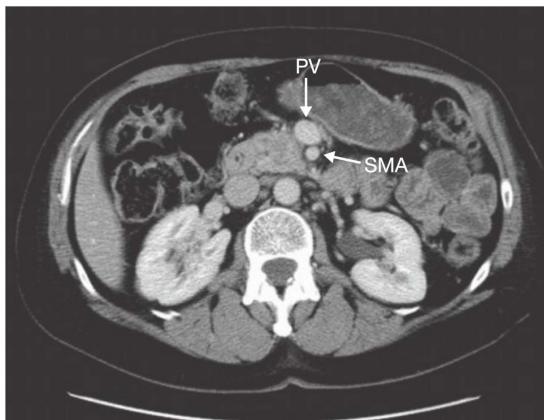
- Physical exam should look for other sources of chronic disease including carotid bruit, jugular venous distension, rales, wheezing, heart murmur, or clubbing of fingers.

**IMAGING AND OTHER DIAGNOSTIC STUDIES**

- “Pancreatic protocol” computed tomography (CT) scan of the chest, abdomen, and pelvis is required for all patients. Pancreatic protocol is a triphasic thin ( $\leq 5$  mm), multislice CT scan with an arterial, venous, and delayed phase in conjunction with sagittal and coronal views. Water is used to opacify the stomach. A properly performed CT scan is perhaps the most critical portion of the preoperative assessment to determine if the patient is a candidate for surgery. The purpose of the CT scan is to detect any metastatic disease and to assess the relationship of the low-density tumor to the surrounding vasculature. Particular attention is paid to the relationship of the tumor to the portal vein (PV), superior mesenteric vein (SMV), superior mesenteric artery (SMA), hepatic artery, and celiac axis. In addition, a CT will aid in identification of aberrant anatomy of the hepatic artery, which is present in 20% of cases and must be noted prior to surgery.
- CT scan of chest is done to evaluate for pulmonary metastasis.
- Based on imaging, there are well-defined consensus criteria from the American Hepato-Pancreato-Biliary Association for resectable, borderline resectable, locally advanced, and metastatic diseases. These criteria have been adopted by the National Comprehensive Cancer Network (NCCN).<sup>3</sup>
- Resectable tumors demonstrate the following:
  - No distant metastases; no radiographic evidence of SMV and PV abutment, distortion, tumor thrombus, or venous encasement; clear fat planes around the celiac axis, hepatic artery, and SMA (FIG 1)

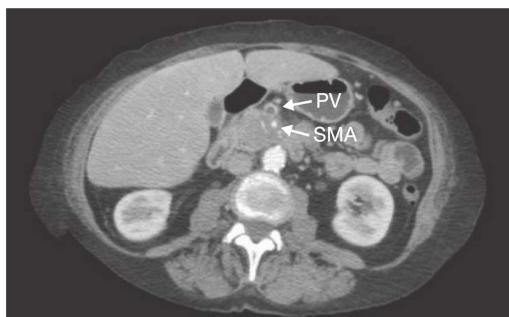


**FIG 1** • CT of a resectable pancreatic cancer. PV, portal vein; SMA, superior mesenteric artery.



**FIG 2** • CT of a borderline resectable pancreatic cancer. There is a loss of the "fat plane" between the SMV/PV confluence. PV, portal vein; SMA, superior mesenteric artery.

- Borderline resectable tumors demonstrate the following:
  - No distant metastases; venous involvement of the SMV/PV demonstrating tumor abutment with or without impingement and narrowing of the lumen, encasement of the SMV/PV but without encasement of the nearby arteries, or short segment venous occlusion resulting from either tumor thrombus or encasement but with suitable vessel proximal and distal to the area of vessel involvement, allowing for safe resection and reconstruction; gastroduodenal artery (GDA) encasement up to the hepatic artery with either short segment encasement or direct abutment of the hepatic artery, without extension to the celiac axis; tumor abutment of the SMA not to exceed 180 degrees of the circumference of the vessel wall (**FIG 2**)
  - Locally advanced tumors demonstrate the following:
    - No distant metastases; unreconstructable SMV/ PV occlusion; greater than 180 degree encasement of SMA, celiac axis, or aortic invasion; metastasis to lymph nodes beyond the field of resection (**FIG 3**)
- Endoscopic ultrasound (EUS). This is an important step in the assessment of many, but not all, pancreatic masses and cystic lesions. EUS is performed to obtain a tissue diagnosis of a solid mass, which will be required if neoadjuvant chemotherapy is planned. Cystic lesions may be characterized by EUS and the fluid may be aspirated and sent for cytology including a mucin stain, carcinoembryonic antigen (CEA) and amylase concentration, and perhaps, genetic analysis. Furthermore, EUS may



**FIG 3** • CT of an unresectable/locally advanced pancreatic cancer. The lesion has encircled the SMA. PV, portal vein.

be used as an adjunct to the CT scan to further evaluate venous involvement and can be more sensitive than CT in detecting a small mass. If enlarged celiac lymph nodes are seen, they may be biopsied. EUS and CT can be compromised by the presence of a bile duct stent so ideally, these tests are performed prior to endoscopic retrograde cholangiopancreatography.

- Endoscopic retrograde cholangiopancreatography (ERCP). ERCP may be used to provide biliary decompression. In cholangiocarcinomas, it is necessary to evaluate the entirety of the biliary tree and see the proximal extent of the stricture. This may require a percutaneous transhepatic cholangiogram. In ampullary carcinomas, the mass can be directly visualized and biopsied. A biliary stent should be placed if neoadjuvant therapy is planned, to allow time for referral to a high-volume pancreas surgery center, and in cases where the serum bilirubin is particularly elevated ( $>10$  mg/dL).<sup>4</sup> Although stent placement has been shown to increase infectious complications, prolonged biliary obstruction causing liver insufficiency and coagulopathy adversely affects surgical outcomes.
- Duplex ultrasound of the neck is performed selectively in patients who may need to undergo PV resection to evaluate the patency of the internal jugular veins. It may also evaluate the carotids in patients at high risk for atherosclerotic disease.
- Octreotide scan. Octreotide scan is a radionuclide scan used for localization of primary and metastatic neuroendocrine tumors. Radioactive octreotide attaches to tumor cells that have receptors for somatostatin. Somatostatin receptor scintigraphy and three-dimensional single-photon emission computed tomography (SPECT) images are taken at 4 hours and 24 hours. The tracer is visible in the thyroid, liver, gallbladder, kidneys, spleen, and urinary bladder; the physiologic uptake by these organs is diffuse. Carcinoid tumors may be seen at 24 hours more clearly than at 4 hours by virtue of reduction in background activity.
- Tumor markers. Serum carbohydrate antigen 19-9 (CA 19-9) is shown to be predictive of outcomes in pancreatic adenocarcinoma. However, CA 19-9 can be falsely elevated in the setting of obstructive jaundice. If it is more than 1,000 U/mL in the absence of jaundice, there should be a high suspicion for metastatic disease.<sup>5</sup> In patients who receive neoadjuvant therapy, CA 19-9 may be used as a marker to assess response. A drop in CA 19-9 of greater than 50% may be predictive of improved survival.<sup>2</sup> A low value is not predictive of favorable biology. Serum chromogranin A should be performed in patients with pancreatic neuroendocrine tumors. Elevated chromogranin A may be followed as a marker; a low value is not predictive of favorable biology.
- Liver function test and coagulation profile: Bile salts are required for absorption of vitamins A, D, E, and K. Patients with biliary obstruction may require vitamin K (10 mg administered intramuscularly three times every day) if the prothrombin time/international normalized ratio (PT/INR) is prolonged. A serum albumin level of less than 3 may indicate the need for preoperative nutritional supplementation.
- Cardiopulmonary clearance and risk assessment by a cardiologist or appropriate internist may aid in perioperative optimization.

## SURGICAL MANAGEMENT

### Preoperative Planning

- Presentation of the case at a multidisciplinary tumor board with radiology, gastroenterology, medical oncology, radiation

oncology, and surgical teams in attendance is optimal in the evaluation of all pancreatic lesions. This allows the case to be reviewed in an objective manner, facilitates enrollment in clinical trials, and allows the development of institutional guidelines of care among all specialties.

- All patients with pancreatic adenocarcinoma, whether resectable, locally advanced, or metastatic, should be offered access to a clinical trial.
- A pancreaticoduodenectomy should be performed at a high-volume center (approximately more than 16 pancreatic resections per year). Resections performed at institutions below that volume have higher perioperative morbidity and mortality rates and worse oncologic outcomes.<sup>6,7</sup>

### DIAGNOSTIC LAPAROSCOPY

- Diagnostic laparoscopy. The value of staging laparoscopy has decreased as the accuracy of CT scanning has improved.<sup>3</sup> Laparoscopy should be performed as a prelude to potential surgical resection in selected patients who have pancreatic adenocarcinoma. We advocate selective laparoscopy on the same day as the planned resection in high-risk patients with potentially advanced disease, large (>4 cm) or borderline resectable tumors after neo-

- Be prepared to alter the sequence of the dissection; anatomic relationships of the tumor drive this up to the point of commitment for resection—unaffected planes should be addressed before embarking on those at risk.

### Positioning

- Supine position with both arms out to the side. Tuck the sheet tight under the bed to ensure bed rails are accessible for retractor placement.
- Turn the head to the right with neck extended to expose the left internal jugular vein.

### INCISION

- Pancreaticoduodenectomy can be performed through a midline incision from xiphoid to umbilicus or through a bilateral subcostal incision. A bilateral subcostal incision may be superior in patients with a shorter body habitus or significant obesity. A bilateral subcostal incision can be

adjuvant therapy, liver lesions too small to characterize or percutaneously biopsy, any ascites fluid, marked weight loss, hypoalbuminemia, and high (>1,000 U/mL) CA 19-9 levels.

- The peritoneum, omentum, and surface of the liver are inspected for evidence of metastasis. A multiport technique with mobilization of the tissues and use of a laparoscopic ultrasound probe is required for a thorough examination.

### INITIAL ASSESSMENT OF RESECTABILITY

- The initial portion of the procedure is an assessment of resectability.
- The liver and visceral and parietal peritoneal surfaces are thoroughly assessed via a systematic four-quadrant exploration including bimanual palpation of the liver and running the small bowel from the ligament of Treitz to the cecum and palpation of the colon.

inferior in patients with a narrow costal angle and may limit exposure to the pelvis in patients with adhesions from previous pelvic surgery.

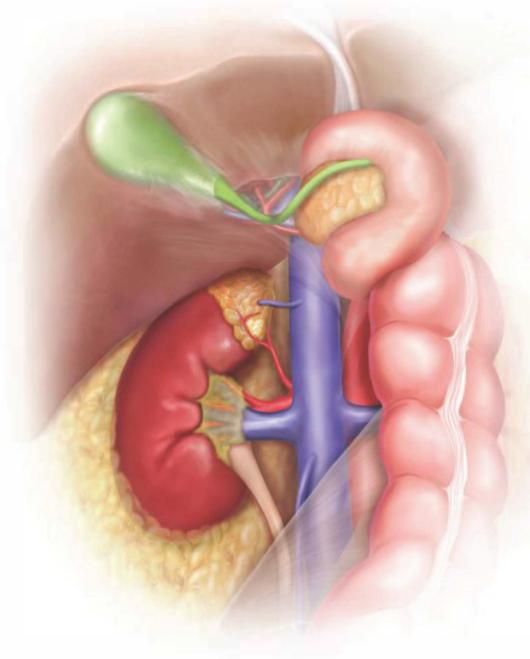
- The falciform ligament is ligated, keeping it long to place over the stump of the GDA at the end of the case.
- Surgical retractor of choice (Bookwalter or Thompson) is placed.

- The gastrohepatic omentum is opened, and the region of the celiac axis is examined for enlarged lymph nodes. The base of the transverse mesocolon to the right of the middle colic vessels is examined for tumor involvement.
- Additional information regarding the extent of the malignancy with respect to the PV, SMA, and so forth will be gleaned as the dissection progresses.

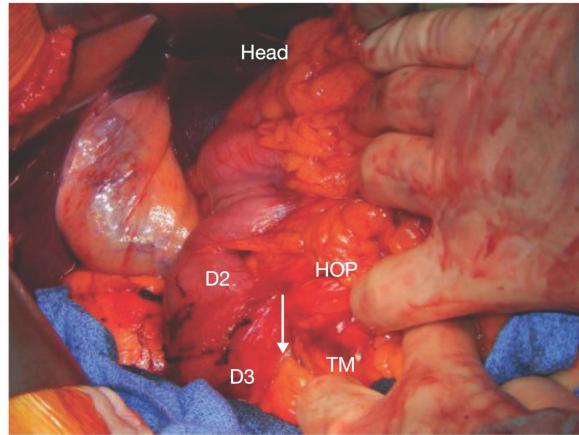
### CATTELL-BRAASCH AND KOCHER MANEUVERS

- The ascending colon and hepatic flexure of the colon are freed of their lateral and superior attachments using an energy device. The colonic mesentery is completely mobilized and reflected medially to expose the second and third portions of the duodenum and the head of the pancreas (FIG 4). An avascular plane between these structures will develop over the third portion of the duodenum and extend up to the inferior border of the neck

of the pancreas (FIG 5). A Kocher maneuver is performed by incising the peritoneum along the lateral edge of duodenum. This incision should be extended cephalad into the foramen of Winslow. Incise the avascular ligament that tethers the third portion of the duodenum inferiorly, allowing further dissection behind the head of the pancreas, thus elevating the duodenum and pancreas from the vena cava and aorta. The duodenum is mobilized medially until the left renal vein is seen crossing over aorta. This will usually also result in fully exposing and dividing the ligament of Treitz from the right side of the patient.



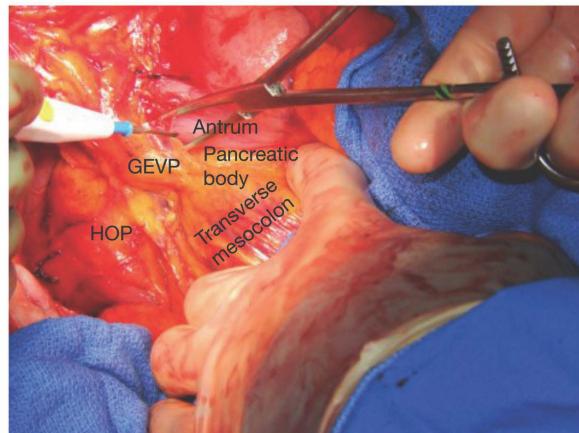
**FIG 4** • Artist's renditions of the Cattell-Braasch maneuver and subsequent wide Kocher maneuver.



**FIG 5** • Operative photograph taken during performance of a Cattell-Braasch maneuver exposing the duodenum and pancreatic head. The white arrow points to the avascular plane between the transverse mesocolon and the head of the pancreas, which in this view has yet to be dissected from the mesentery and omentum. TM, transverse mesocolon; D2, second portion of duodenum; D3, third portion of duodenum; HOP, head of pancreas.

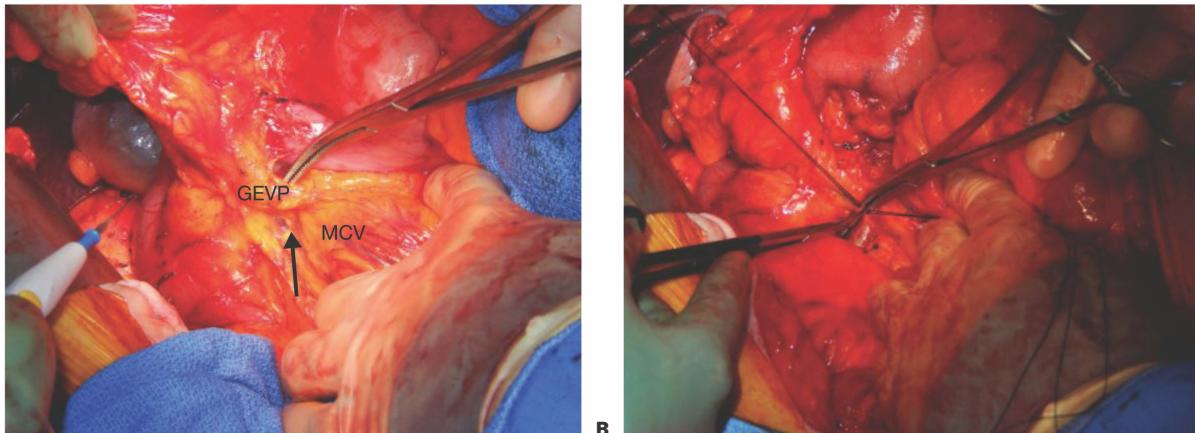
## EXPOSURE OF THE INFRAPANCREATIC SUPERIOR MESENTERIC VEIN

- The gastrocolic omentum is divided, opening the lesser sac and exposing the body and tail of the pancreas. As the gastrocolic ligament is divided, the dissection is kept outside of the gastroepiploic vessels to preserve the gastric vasculature and blood supply to the duodenal cuff. Dissection proceeds from the patient's left to right with the goal of defining the avascular fusion plane between the omentum, the right gastroepiploic vascular pedicle, and the transverse mesocolon. This plane is fully mobilized to expose the pancreatic head. Congenital adhesions of the antrum to the anterior pancreas are then taken along the inferior border of the pancreas working toward the gastroepiploic vein (**FIG 6**).
- Dissect the anterior aspect of the middle colic vein(s) and circumferentially dissect the gastroepiploic vein as it inserts into the anterior surface of the SMV at the inferior border of the neck of the pancreas. They may enter as a common trunk (gastrocolic trunk) or separately. There is often a tributary vein inserting into the cephalad (unvisualized) aspect of the gastroepiploic vein. Although contrainuitive, the safest place to get around the vein is at the level of the SMV—not a little bit away from it. Once isolated, the gastroepiploic vein is ligated and divided (**FIG 7**). All efforts should focus on preservation of the middle colic vein; however, in rare circumstances, it is prudently divided based on anatomy to prevent traction injury or tearing of the vessels later in the dissection.



**FIG 6** • Take down the congenital attachments of the posterior stomach to the anterior aspect of the pancreatic body. After division of the gastrocolic omentum, dissect along the inferior border of the pancreas, working from the patient's right to left up to the gastroepiploic vascular pedicle (GEVP). The head of the pancreas (HOP) is visualized on the left.

- Dissection is continued to further mobilize inferior border of the pancreas to identify and expose the anterior surface of the SMV (**FIG 8**).
- At this point, the anterior aspect of the pancreas is fully exposed and the inferior aspect of the neck and body has

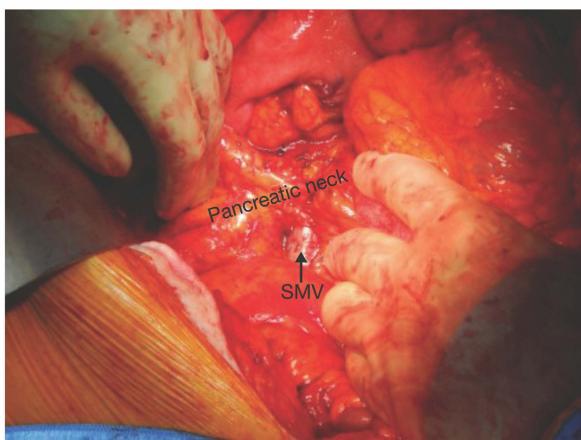


**FIG 7** • **A**, The gastroepiploic vein is circumferentially dissected (black arrow marks the course of the SMV) and **(B)** ligated between ligatures and divided. GEVP, gastroepiploic vascular pedicle; MCV, middle colic vein.

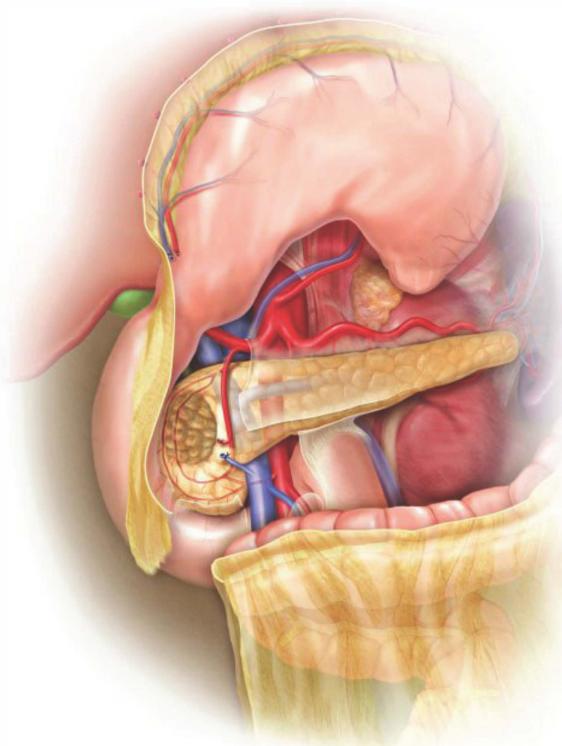
been dissected, including the anterior aspect of the SMV (**FIG 9**).

- The plane anterior to the SMV as it courses behind the pancreatic neck is now initially assessed. Completion of this retropancreatic tunnel should be deferred until the PV is exposed cephalad to the pancreatic neck in subsequent steps. The authors recommend the use of a blunt-tipped instrument such as a Kelly clamp to perform this exposure. Care must be taken to carefully assess potential involvement of this plane by tumor or inflammation during this step. Inadvertent injury to the SMV at this point will result in catastrophic hemorrhage that can be very difficult to control given the limited exposure.
- The relation of the tumor to the SMV and artery can now be relatively well assessed by palpation; however,

palpation is not completely reliable, as posterior or lateral extension of the lesion that compromises these margins cannot be completely determined until later in the operation when the neck of the pancreas is divided and the surgeon is committed to resection.



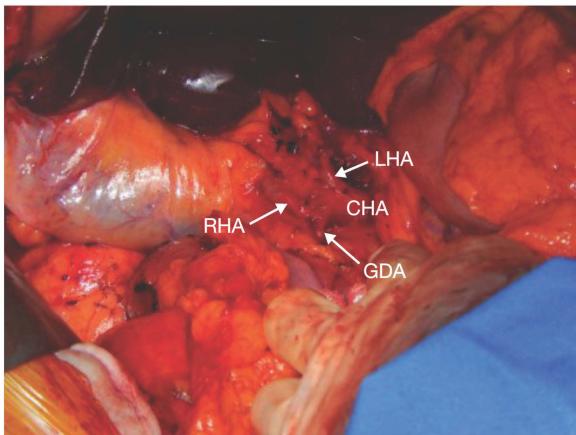
**FIG 8** • Once the gastroepiploic vein has been divided, the anterior aspect of the SMV is exposed. This dissection of the SMV is continued inferiorly to the caudad aspect of the third portion of the duodenum.



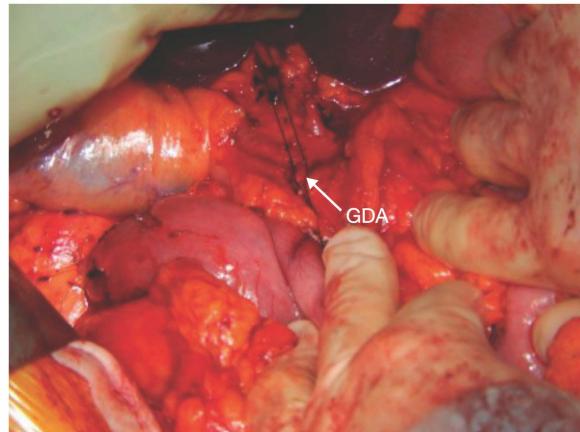
**FIG 9** • Schematic representation of exposure of the pancreatic head, neck, and body including the anterior aspect of the SMV.

### DISSECTION OF THE PORTA HEPATIS

- The porta hepatis is palpated by placing a finger through the foramen of Winslow. Enlarged or firm lymph nodes that can be swept down toward the head of the pancreas with the specimen do not preclude resection.
- The presence of an aberrant right hepatic artery or other anomalies should be identified during review of the preoperative CT scan. Regardless, prior to initiating the dissection of the porta hepatis, it is important to assess for aberrant hepatic arterial anatomy, which is present in approximately 20% of patients, by palpation of the porta hepatis. The aberrant artery commonly arises from the SMA posterior to the pancreas and ascends parallel in a lateral and posterior location to the common bile duct and PV. Possible alterations in this anatomy are reviewed in Part 3, Chapter 15.
- The proximal hepatic artery is identified usually by removing a lymph node that lies anterior to the artery.
- The hepatic artery is dissected and traced toward the porta hepatis. Small vessels in this area can be ligated with silk ligatures or bipolar electrocautery to prevent bothersome hemorrhage that makes subsequent dissection more tedious.
- Inferior retraction of the pylorus will expose a band of tension from the hepatic artery—this is the right gastric artery and this is ligated and divided. The GDA is identified posterior to the right gastric artery coming directly off the caudad aspect of the hepatic artery (**FIG 10**).

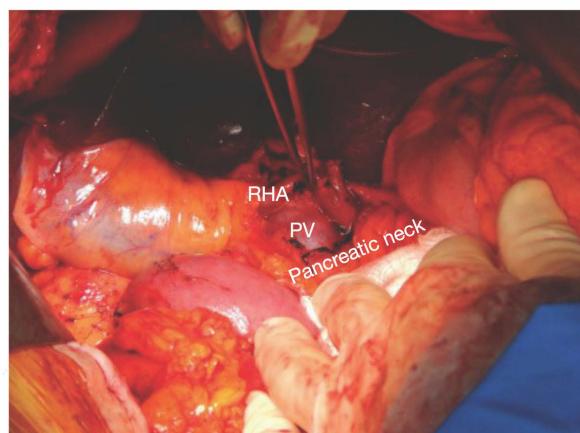


**FIG 10** • Operative exposure of the common hepatic artery (CHA) and its named branches. The demonstrated anatomy is not classic in that the bifurcation of the right and left hepatic artery (RHA and LHA) occurs prior to the origin of the GDA. The GDA arises from the RHA. The right gastric artery has been ligated and divided in this photograph.



**FIG 11** • The GDA is ligated and divided. The authors recommend additional suture ligation or oversewing the GDA stump and marking it with a surgical clip.

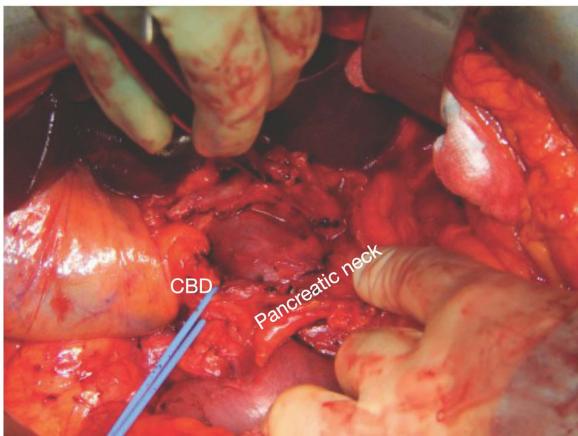
- Once the GDA is identified (**FIG 11**), it is circumferentially dissected and test clamped to ensure that a strong pulse remains in the proper hepatic artery. This test rules out a hemodynamically significant celiac stenosis leading to hepatic blood flow depending on collateral circulation through the pancreatic head. If this clinical scenario is present, proceeding with resection is contraindicated.
- The GDA is doubly ligated and a surgical clip applied.
- Once the GDA is divided, the hepatic artery is retracted medially and the common bile duct is retracted laterally to reveal the anterior surface of the PV (**FIG 12**).



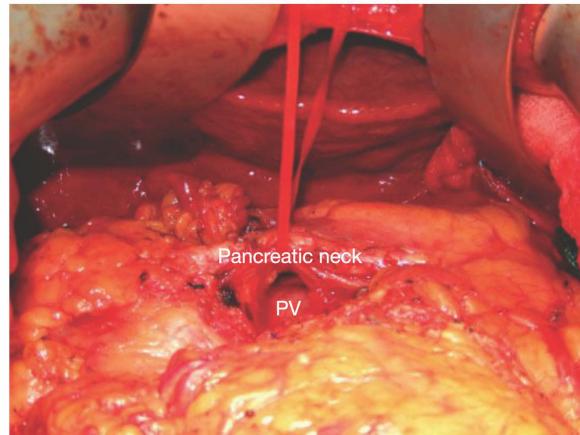
**FIG 12** • Division of the GDA facilitates medial and cephalad retraction of the hepatic artery and its branches (RHA), exposing the PV cephalad to the pancreatic neck.

## CREATION OF A TUNNEL BETWEEN THE PANCREATIC NECK AND PORTAL VEIN

- The authors prefer to complete this step prior to dissection of the bile duct as findings may impact the decision to proceed.
- Dissection is performed only on the anterior surface of the vein.
- Dissect the PV superior to the neck of the pancreas. If there is no tumor involvement, the neck of the pancreas will separate from the vein easily. A large, blunt-tipped clamp is a safe instrument to use for this dissection.
- The tunnel under the neck of the pancreas can then be completed mostly under direct vision as one progresses from both the inferior and superior aspects of the pancreas (**FIG 13**).
- A vessel loop or umbilical tape is then placed under the neck of the pancreas.
- The common bile duct or hepatic duct (depending on the need for margin) is circumferentially dissected and a vessel loop is placed around the duct (**FIG 14**).

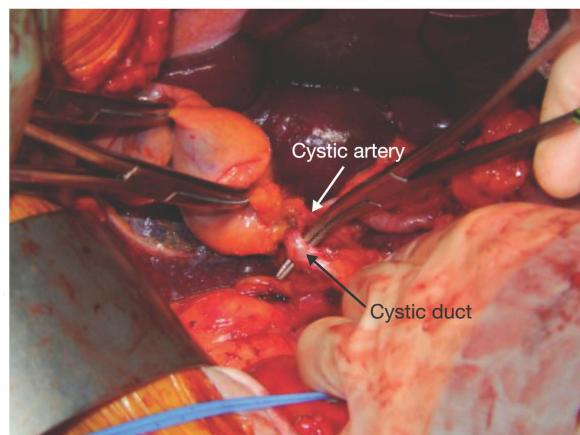


**FIG 13** • To circumferentially dissect the common bile duct (CBD), continue working anterior to posterior along the lateral margin of the PV establishing a plane between the PV and the CBD. The lateral lymphatic tissues are also dissected so they remain with the specimen. The encircled CBD can be controlled with a vessel loop. If a replaced hepatic artery is present, use care to ensure you establish a plane between the bile duct and the artery.

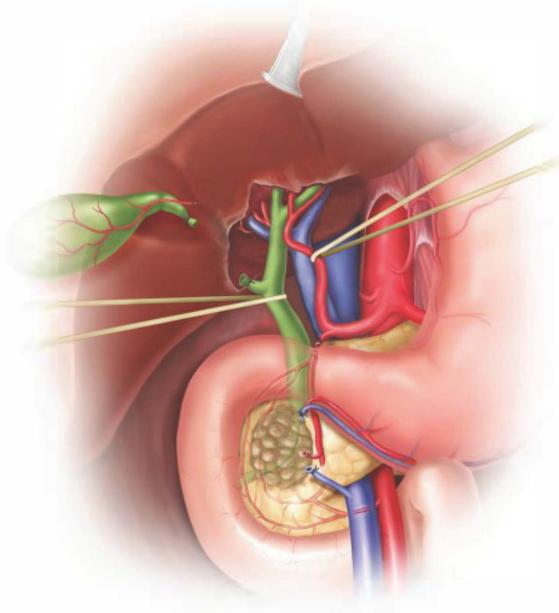


**FIG 14** • Complete the dissection of the anterior aspect of the PV from the neck of the pancreas. An umbilical tape can be placed to facilitate subsequent parenchymal transection.

- The cystic duct and artery are dissected, ligated, and divided (**FIG 15**). A cholecystectomy is performed. Alternatively, it is safer to perform a retrograde dissection of the gallbladder if inflammation is present.
- At this point (**FIG 16**), one must commit to resection or abort.



**FIG 15** • Cholecystectomy is performed. The cystic duct and artery are dissected, controlled with ligatures, and divided.

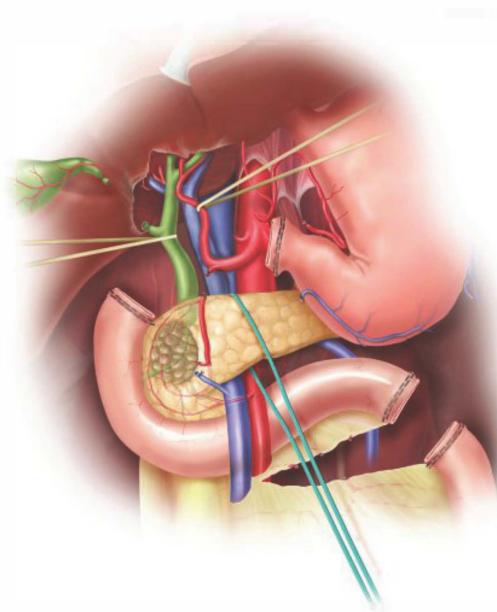


**FIG 16** • Schematic drawing of the dissection at the point of decision to proceed or abort. The next step commits to resection.

### DIVISION OF THE DUODENUM

- If the operative plan is for pyloric preservation, the stomach and proximal duodenum are mobilized off the pancreas, preserving the gastroepiploic vessels down to the pylorus.
- Either the duodenum is divided 1.5 to 2 cm distal to the pylorus-preserving pancreaticoduodenectomy (PPPD) or, alternatively, the antrum is divided (**FIG 17**).

- Antrum division is performed at the division of the vagus nerves of Latarjet ("crow's feet") usually at the third or fourth transverse vein on the lesser curvature and at the confluence of gastroepiploic veins on the greater curvature.
- If the pylorus is preserved, the authors typically digitally dilate the pylorus prior to reconstruction just prior to the duodenojejunral anastomosis.



**FIG 17** • Division of the duodenum and the jejunum with a GIA stapler. The point of duodenal transaction should be at least 2 cm distal to the pylorus. Alternatively and in line with the classic performance of the operation, the antrum is divided. The jejunum is divided distal to the LT. The point of transaction is based on the vascular arcade and mesenteric length. The distal limb must reach the right upper quadrant without tension. The mesentery of the proximal limb is controlled and divided adjacent to the bowel wall to minimize risk of injury to the superior mesenteric vessels.

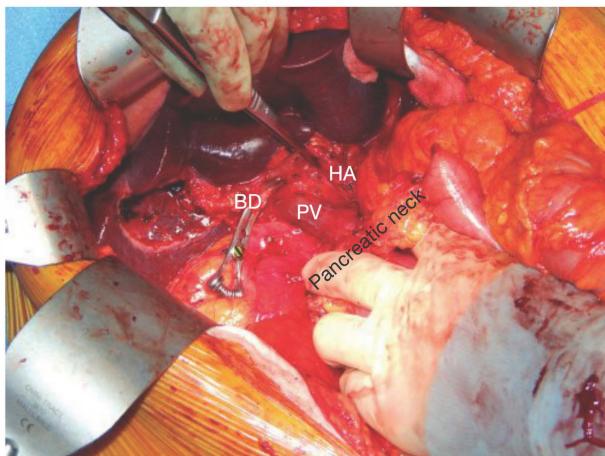
## TAKEDOWN OF THE LIGAMENT OF TREITZ

- The jejunum is divided approximately 10 cm beyond the ligament of Treitz (LT). Careful attention is made to avoid injury to the inferior mesenteric vein just to the left of the LT.
- The mesentery of jejunum is ligated until the jejunum can be delivered posterior to the superior mesenteric vessels from left to right.
- The authors recommend performing the majority of this dissection from the left side of the patient and mobilizing as much as possible from this same side of the base of the mesentery. Dissection is continued proximally to divide and control the mesentery of the fourth and third portion of the duodenum. The visualization is maximized in this manner and this avoids moving the specimen back and forth and repositioning of retractors.
- The mesentery can be taken with ties; however, many surgeons have found that energy devices may speed this portion. Care must be taken as the dissection approaches the mesenteric vessels—the plane of dissection is the bowel wall.

## DIVISION OF BILE DUCT

- The common hepatic bile duct is then sharply divided, usually above the entrance of the cystic duct.
- If present, the biliary stent is removed and passed from the operative field as a contaminated object. Of note, metallic stents do not impact division of the bile duct and can be extracted with minimal resistance.
- Some surgeons obtain cultures of the bile and continue directed, postoperative antibiotic therapy.

- A bulldog clamp is placed on the bile duct to prevent bile from contaminating the field (FIG 18). The distal bile duct is oversewn and the ends of the suture left elongated to orient the pathologist to this important margin.
- The distal bile duct and associated lymphatic tissue is then further dissected down along the anterior plane of the PV.

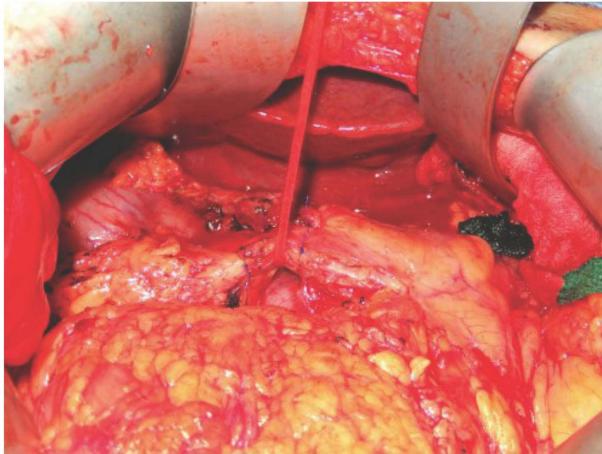


**FIG 18** • Division of the bile duct. A bulldog clamp is placed proximally to prevent ongoing contamination of the operative field with bile and maintain hemostasis. The bile duct is sharply divided. If present and easily retrievable, the biliary stent is removed and passed off the field. It should be catalogued as removed by the pathologist. The distal bile duct is sutured closed. The ends of this suture are left long to orient the pathologist. *BD*, bile duct; *HA*, hepatic artery; *PV*, portal vein.

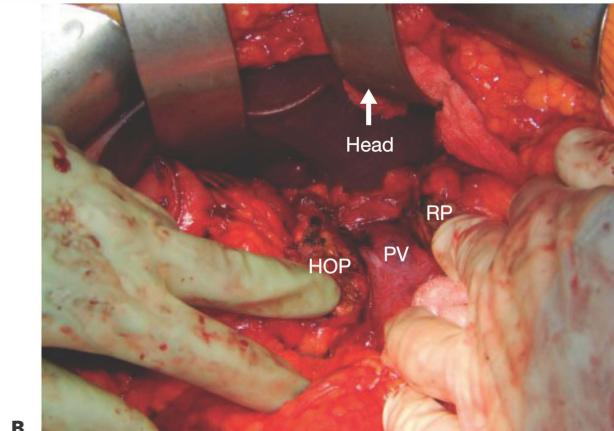
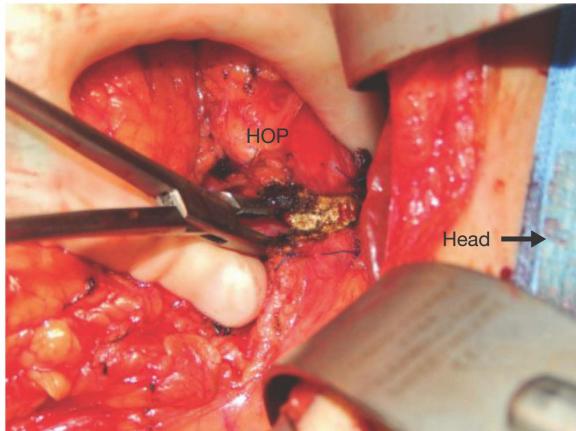
## DIVISION OF THE PANCREAS

- Hemostatic traction sutures are placed on the inferior and superior borders of the pancreas around the transverse pancreaticoduodenal vessels prior to division. These sutures should be placed to intentionally ligate the longitudinal arteries within the pancreas; however, care must be taken to ensure they do not entrap the pancreatic duct (FIG 19).

- The pancreatic neck is divided anterior to the PV (FIG 20). The authors would divide the pancreas with electrocautery on the superior and inferior ends and with the scalpel through the midsection of the pancreas to prevent cautery injury and assist in identification of pancreatic duct. Division is performed just anterior to the PV with a large blunt-tipped clamp being placed behind the pancreas to protect the vein.



**FIG 19** • Place sutures at the proximal and distal margins of the pancreatic neck to control the longitudinal arteries and provide retraction.

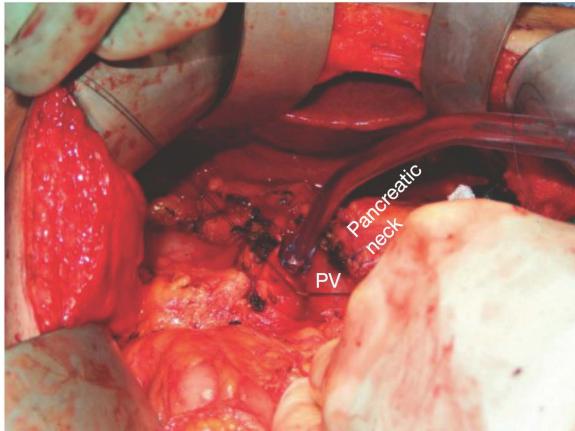


**FIG 20** • Divide the pancreatic neck. **A.** This is ideally performed sharply with judicious use of cautery to control hemorrhage to facilitate pathologic assessment of the margin. **B.** Once completed, the anterior aspect of the PV is fully exposed. *RP*, remnant pancreas; *HOP*, head of pancreas specimen; *PV*, portal vein.

### DISSECTION OFF THE LATERAL ASPECT OF THE SUPERIOR MESENTERIC-PORTAL VEIN CONFLUENCE

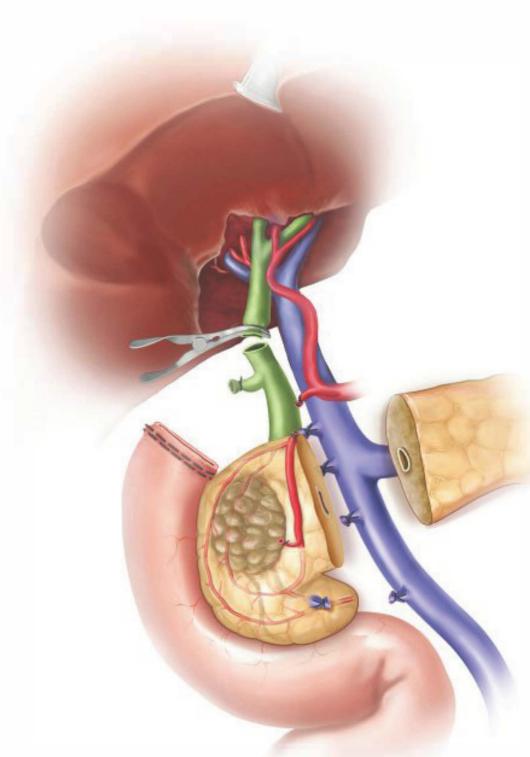
- The pancreatic head and uncinate process are then dissected off of the right lateral aspect of the SMV, ligating the fragile branches draining the head and uncinate process into the PV (FIG 21).
- Superiorly, as the pancreatic head is being retracted inferiorly and laterally, the small venous tributaries from the PV and SMV to the pancreatic head including the superior pancreaticoduodenal vein (vein of Belcher), which inserts at the superior lateral surface of the PV, are ligated.

- Inferiorly, as the pancreatic head is retracted superiorly and laterally, the first jejunal branch will be encountered. The authors suggest ligating the first jejunal branch as it comes off of the SMV. If this is not ligated close to the SMV, it may be injured during the dissection and retract behind the SMA. Efforts to control bleeding once the vessel has retracted may result in injury to the SMA. If the tumor is inferior in location, this ligation is critical. In cases where the tumor is away from the first jejunal branch of the SMV, it can be preserved.
- The SMV is then fully mobilized off of the uncinate process to reveal the SMV/PV groove. The vein must be entirely mobilized away from the head of the pancreas to allow for maximal retroperitoneal margin resection (FIG 22).



**FIG 21** • Ligate and divide the lateral venous branches of the pancreas inserting into the SMV/PV. Beware the first jejunal branch of the SMV. It inserts into the SMV posteriorly and receives a branch from the uncinate process. PV, portal vein.

- If the lesion is adhered to the SMV, PV, or confluence of these vessels, obtain vascular control by circumferentially dissecting the SMV. Mobilize the body of the pancreas off the splenoportal confluence and off the proximal splenic vein. Encircle the splenic vein with a vessel loop as well, and encircle the PV superiorly with a vessel loop. Once venous vascular control is achieved, the dissection then proceeds medial to the SMV directly anterior down onto the SMA and is continued around the right lateral aspect of the SMA, retracting the specimen laterally and mobilizing the specimen up so that it is then only attached by the venous involvement and is otherwise completely free. Part 3, Chapter 39 discusses PV resection and reconstruction.

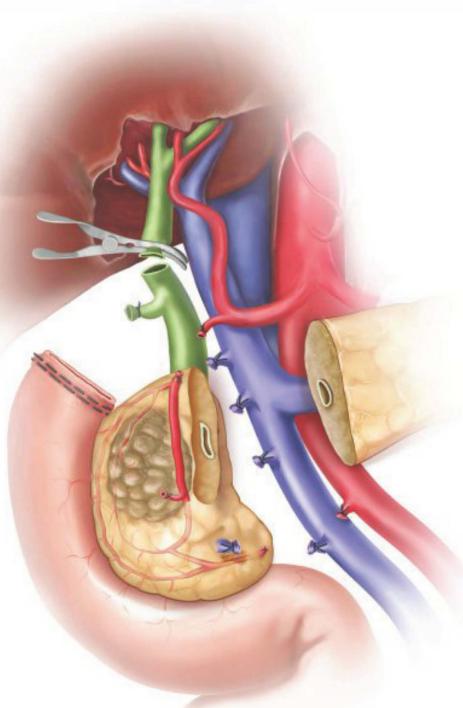


**FIG 22** • Dissect the anterior and lateral surface of the SMA. The splanchnic nerves and lymphatics in this region can make identification of the inferior pancreaticoduodenal artery or arteries challenging. Avoid the impulse to divide these structures with an energy device alone—pseudoaneurysm in the setting of pancreatic fistula from this site is universally life threatening.

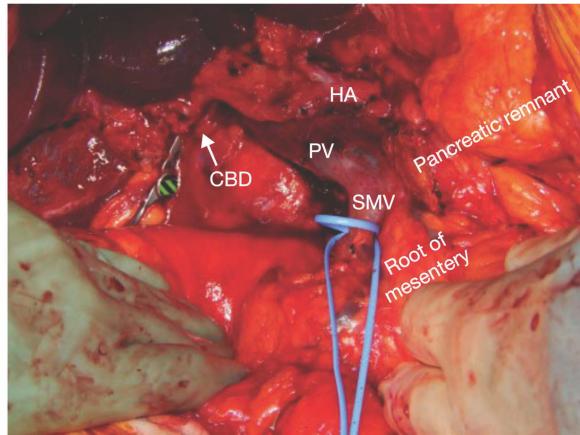
### COMPLETION OF THE RETROPERITONEAL AND SUPERIOR MESENTERIC ARTERY DISSECTION

- In cases without vein involvement, the superior mesenteric-portal vein (SMPV) confluence is retracted medially with a peanut or vein retractor to allow exposure of the retroperitoneal attachments to the SMA.
- The uncinate process is then dissected off of the posterior and right lateral aspect of the SMA, removing all associated autonomic nerve tissue so that the dissection plane is along the adventitia of the SMA. This can be the most tedious portion of the operation, but thoroughly clearing all tissue from the mesenteric vessels minimizes the risk of a margin-positive resection.

- The authors recommend taking the retroperitoneal margin in a controlled fashion with small bites separating out the tissue and division with either suture ties or energy device. They prefer ligation of the inferior pancreaticoduodenal artery and any lesser, unnamed nutrient arteries arising from the SMA (FIG 23). The authors think that use of a stapler for this portion of the procedure leaves tissue behind on the SMA and will increase the incidence of R1 resections.
- If an energy device is used on this portion, caution must be taken to avoid lateral spread to the SMA which can result in a catastrophic, postoperative SMA pseudoaneurysm.
- Once the pancreatic specimen is out (FIG 24), the remaining pancreatic neck should be fully mobilized approximately 2 to 3 cm off of the splenic artery and vein to facilitate the reconstruction.



**FIG 23** • Operative image of the completed dissection. PV, portal vein; SMV, superior mesenteric vein; CBD, common bile duct.



**FIG 24** • Operative image of the completed dissection.

### ORIENTING THE SPECIMEN FOR PATHOLOGIC ANALYSIS

- Before the specimen is sent to pathology, it is critical that the specimen be labeled by the surgeon in a standardized fashion to facilitate communication with the pathologist. We place sutures on the bile duct, pancreatic neck, and retroperitoneal/SMA margin. The SMA margin cannot be marked retrospectively. Furthermore, if any portion of the SMV or PV was resected, the vein should be marked and sent for frozen section.

- Positive resection margins of the pancreatic neck or bile duct may warrant further resection, but recently forwarded data would suggest that this maneuver does not impact outcome.
- If there is a positive margin on the SMA margin, no further tissue can be taken and gold fiducial markers can be left in place for postoperative radiation therapy.

### PEARLS AND PITFALLS

Preoperative assessment	<ul style="list-style-type: none"> <li>Not adequately identifying a replaced hepatic artery can result in injury leading to an ischemic injury to the liver and possibly subsequent liver failure.</li> </ul>
Opening of the lesser sac	<ul style="list-style-type: none"> <li>Ligate the gastroepiploic and sometimes middle colic veins early. This provides improved exposure of the SMV and prevents a traction injury to the vein.</li> </ul>
Dissection of the SMV/PV confluence	<ul style="list-style-type: none"> <li>First jejunal branch not being properly ligated can result in division or injury to the vein with it retracting behind the SMA. Attempts to control this bleeding may result in iatrogenic injury to the SMA.</li> </ul>
Retroperitoneal dissection	<ul style="list-style-type: none"> <li>Complete removal of uncinate process and the mesenteric soft tissue from the SMA decreases the chance of an R1 resection.</li> </ul>

Vein involvement	■ If the tumor is adhered to SMPV confluence, we obtain vascular control of the PV, SMV, and splenic vein and dissect medial to the PV/SMV and perform an artery-first dissection. Completing this dissection first decreases clamp time once the vein is divided.
Pancreatic neck	■ Mobilization of the pancreatic neck off of the splenic artery and vein facilitates a secure reconstruction and anastomosis.
Pylorus preservation	■ If the pylorus is preserved, the authors typically digitally dilate the pylorus prior to reconstruction once the staple line is removed. The authors think this reduces postoperative gastroparesis.

## POSTOPERATIVE CARE

- Patients should be monitored in the intensive care unit for hemodynamic changes, urine output, or changes in drain characteristics.
- Monitoring of drains: The authors would check postoperative drain amylase on postoperative days 1 and 3. If a pancreatic leak exists, the drain should be left in place. In addition, the drain fluid should be monitored for change in character to bilious or sanguineous. If no pancreatic or biliary leak exists, the drains should be removed on postoperative day 3.
- A low amylase level in the drain does not ensure the absence of a leak. Tachycardia and leukocytosis should drive concern and may warrant CT evaluation.
- Patients should be placed on perioperative antibiotics. If the bile cultures come back positive, the authors continue culture-directed antibiotics for 7 days.

## OUTCOMES

- At high-volume institutions, 30-day mortality rates are less than 1.5% and 90-day mortality rates are 4%.
- The overall 1-year survival rate of people with pancreatic cancer is 26%, and the 5-year survival rate is approximately 6%. If the cancer is detected at an early stage when surgical removal of the tumor is possible, the 5-year survival rate is about 22%.

## COMPLICATIONS

- Pancreatic fistula
- Delayed gastric emptying

- Biliary fistula
- Fistula-associated pseudoaneurysm—uncommon. Often, a herald bleed presents as an episode of hypotension accompanied by hematemesis and blood from the intraabdominal drain. These should be treated emergently with angiography
- Wound infection
- Abdominal abscess

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