Partial Pancreatoduodenectomy

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Indications

- Tumors of the head of pancreas, duodenum, ampulla, or distal bile duct that have been determined to be resectable based on imaging and endoscopy
- Pancreatic cystic neoplasms (i.e., intraductal papillary mucinous neoplasms [IPMNs]) that are high-risk for malignant degeneration
- Select patients with chronic pancreatitis and intractable pain who have failed medical management and whose disease is limited to the head of the pancreas
- Rare cases of pancreatic head involvement and/or significant duodenal involvement by adjacent tumor

Contraindications

- Absolute contraindications:
  - Patients with metastatic disease who will obtain no survival benefit from resection
  - Extensive tumor involvement of superior mesenteric artery (SMA)

- Relative contraindications:
  - Extensive involvement of portal vein (PV), superior mesenteric vein (SMV), and hepatic artery (HA): resectability of a pancreatic head mass is often determined by the involvement of these critical vessels. While vascular resections can be performed, these cases must be approached with caution and understanding of the increased risk of postoperative complications, morbidity, and mortality.
  - Hospitals or surgical teams that lack experience in pancreatoduodenectomy: studies have shown improved patient outcomes when this operation and resultant postoperative care are performed at high-volume centers.

Preoperative Preparation

- High resolution imaging with computed tomography (CT) or magnetic resonance imaging (MRI) to obtain accurate staging and resectability.
- Routine preoperative biliary decompression has not been shown to be beneficial and is usually only required if the bilirubin is extremely high (>20 mg/dL).
- Neoadjuvant chemotherapy (with/without radiation therapy) should be considered for pancreatic adenocarcinoma; for patients with borderline resectable disease, neoadjuvant treatment can lead to an increased resectability rate and an improved oncologic resection.
- Vitamin K should also be considered in all jaundiced patients, as many have occult vitamin K deficiency even with normal coagulation panels.
- Perioperative antibiotics.
- Epidural catheter for post-operative analgesia.
- Nasogastric tube (NGT) for decompression of the stomach during the procedure.

Pitfalls and Danger Points

- Intraoperative hemorrhage
- Injury or inadvertent ligation of superior mesenteric artery or vein, an anomalous hepatic artery or the portal vein
- Failure of pancreaticojejunal anastomosis with leakage
- Failure of hepaticojejunal anastomosis with leakage (unusual)

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- Failure of gastrojejunal anastomosis with leakage (rare)
- Postoperative hemorrhage (typically gastroduodenal artery blowout secondary to pancreatic leak)
- Postoperative sepsis

Operative Strategy

The operation may be conceptualized as consisting of three stages: assessment of resectability, resection of the specimen, and reconstruction for enteric continuity. The operative technique will describe a standard pancreatoduodenectomy, with resection of the gastric antrum and pylorus, and a gastrojejunostomy. Modifications of technique for a pylorus-preserving pancreatoduodenectomy will be outlined afterwards. Diagnostic laparoscopy is usually performed as a first step, to exclude small metastatic deposits not seen on preoperative imaging studies.

Assessment of Pathology to Determine Resectability

Before any major, irreversible resections of bowel and/or vessels are done, an evaluation of resectability of the lesion should be completed. The liver should be palpated, as well as the mass itself. The root of the small bowel mesentery and celiac axis nodes should be evaluated. A complete kocherization of the duodenum, palpation and visualization of the pancreas, and assessment of the SMV, SMA, and PV should be included in the evaluation for resectability. Of note, lymph node involvement along the gastrohepatic or gastroduodenal artery adjacent to the malignancy is not a contraindication to resection. Patients with preoperative biliary stent placement may have enlarged lymph nodes due to inflammatory reaction. Any decision to abort the procedure should be confirmed with definitive intraoperative frozen section.

Most patients will go to the operating room with a pathologic diagnosis. If there is some doubt in the diagnosis or need of proof of malignancy, then intraoperative biopsy can be performed prior to resection. In general though, the decision to operate is made preoperatively. The lesion in the head of the pancreas can be exposed by dividing the omentum and entering the lesser sac. Typically, a fine-needle aspiration cytology will be sufficient for confirmation, but a transduodenal core biopsy may be necessary if more tissue is needed. Occasionally, it is necessary to proceed without confirmation of malignancy.

Avoiding and Managing Intraoperative Hemorrhage

The greatest risk of major intraoperative hemorrhage occurs when the surgeon is dissecting the PV/SMV tunnel under the neck of the pancreas. If the vein is lacerated while making the tunnel, controlling the hemorrhage is extremely difficult due to poor exposure caused by the overlying pancreas gland. Temporary control of hemorrhage is generally possible in this situation if the surgeon compresses the vein against the tumor by passing the left hand behind the head of the pancreas. An experienced assistant then divides the neck of the pancreas anterior and just to the left of the SMV. In some cases, it is necessary to isolate and temporarily occlude the splenic, inferior mesenteric, superior mesenteric, coronary, and portal veins to achieve proximal and distal control.

Vascular Resections

The need for a vascular resection during pancreatoduodenectomy can lead to significant complications both intraoperatively and postoperatively. Pre-operative imaging can often identify patients who have a higher chance of requiring a vascular resection. While vascular resection and reconstruction may be technically possible in many cases, these patients should be selected carefully, and the operation should be done with a team that has significant experience with these types of resections. Prior to any planned vascular resection, proximal and distal control must be obtained in order to safely complete the resection and reconstruction.

If tumor has indeed invaded the portal vein, a patch or a segment of vein may have to be excised. Partial resection of the vein should ideally be closed perpendicular to the course of the vein as to avoid narrowing of the vessel. Alternatively, a vein patch can be used. If a short segment of vein is resected, an end-to-end anastomosis of the PV to the SMV is usually possible. Ligation of the splenic vein can often provide enough laxity to create a tension-free anastomosis. To replace longer segments of resected PV/SMV, an interposition vein graft may be needed. Sources of conduit include saphenous vein, left renal vein, internal jugular vein, or common femoral vein. The choice of conduit is dependent on size of PV and SMV, as a close match in diameter is preferred. Acute ligation of the PV is often fatal and should be avoided at all costs.

Avoiding and Managing Postoperative Hemorrhage

A possible disastrous complication is exsanguination from a gastroduodenal (GDA) stump blowout. When this happens, it typically occurs around postoperative day (POD) 5–14 in the setting of a pancreatic leak. Classic presentation begins with a sentinel bleed that in the drain or hematemesis and then progresses to uncontrolled and rapid exsanguination. A CT angiogram should be performed immediately and any suspicion of a pseudoaneurysm of the GDA treated with

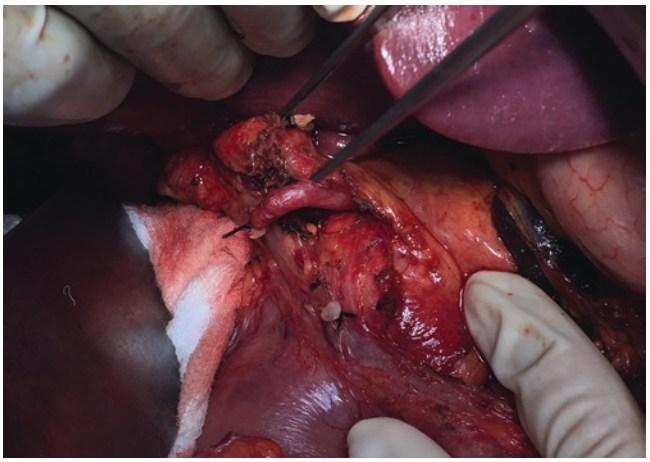


Fig. 96.1

embolization. Operative intervention is reserved only for cases where embolization is not possible or fails. Ideally, a short stump should be left on the common hepatic artery at the origin of the GDA so an interventional radiologist can place their coils without risking occlusion of the common hepatic artery (Fig. 96.1).

Avoiding Leakage from the Pancreatojejunal Anastomosis

Leakage from the pancreatojejunal anastomosis is the Achilles heel of the Whipple procedure, and is documented to occur in approximately 15% of cases, even at high-volume centers. Failure of the pancreatic anastomosis is more common in patients with a soft gland and small pancreatic duct, such as seen in patients with carcinoma of the distal portion of the common bile duct (CBD) or the duodenum because these patients do not typically develop obstruction of the pancreatic duct, which is frequently associated with low-grade pancreatitis and a firm pancreas. Both obstruction and pancreatitis produce thickening of the pancreatic duct and the pancreatic parenchyma. Anastomosis to a soft pancreas can be technically challenging.

Operative Technique

Diagnostic Laparoscopy

The first step of the operation is a diagnostic laparoscopy (with the exception of pre-malignant cysts) to ensure there is no gross metastatic disease to the peritoneum or liver which was not detected on pre-operative imaging. With the increased use of neoadjuvant chemotherapy and repeat imaging prior to surgery, there appear to be fewer cases of patients with grossly metastatic disease undergoing surgery. Not all patients need a diagnostic laparoscopy, but it is a simple, inexpensive procedure that could spare a patient undergoing a non-therapeutic laparotomy. The peritoneum, liver, and omentum should be inspected for any gross metastatic disease. Any suspicious nodules should be biopsied and confirmed to be benign prior to proceeding.

Incision and Exposure

A midline incision from the xiphoid to or just below the umbilicus will usually provide adequate exposure. The extension of the incision will be based on body habitus with a longer incision required for patients with higher body mass indexes (BMIs). Some surgeons prefer a bilateral subcostal incision, with or without an upper midline incision to create a chevron incision. This will provide excellent exposure, but patients may experience more postoperative pain, respiratory splinting, and a diminished cosmetic result.

Transect the round ligament, either with an energy device or ligate it with 0-silk ties. Some surgeons choose to use the tied ligament for retraction of the liver, or to wrap around the pancreatic anastomosis at the completion of the case. A wound protector may be placed in an attempt to decrease the risk of a surgical site infection (SSI). Then place a self-retaining retractor to allow for exposure of the operative field, which will include access to the hepatic flexure on the right, the porta hepatis superiorly, the stomach on the left, and the ligament of Treitz inferiorly (Fig. 96.2).

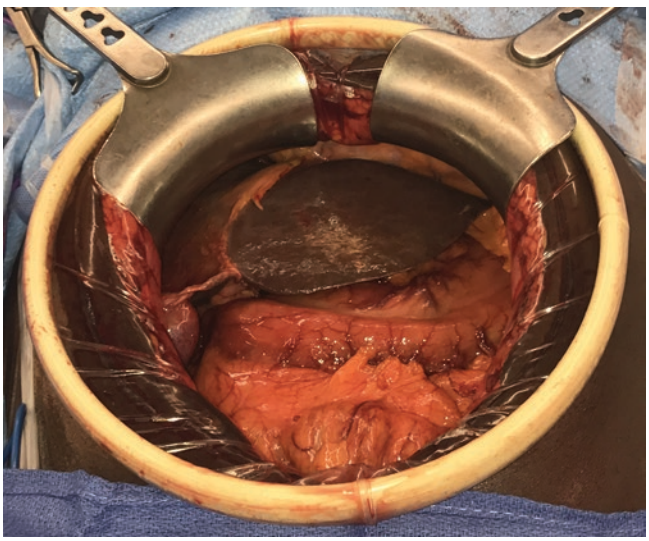


Fig. 96.2

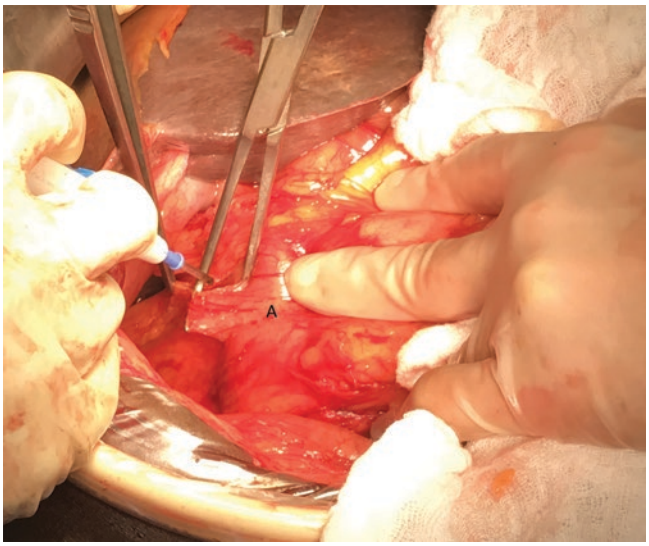


Fig. 96.3

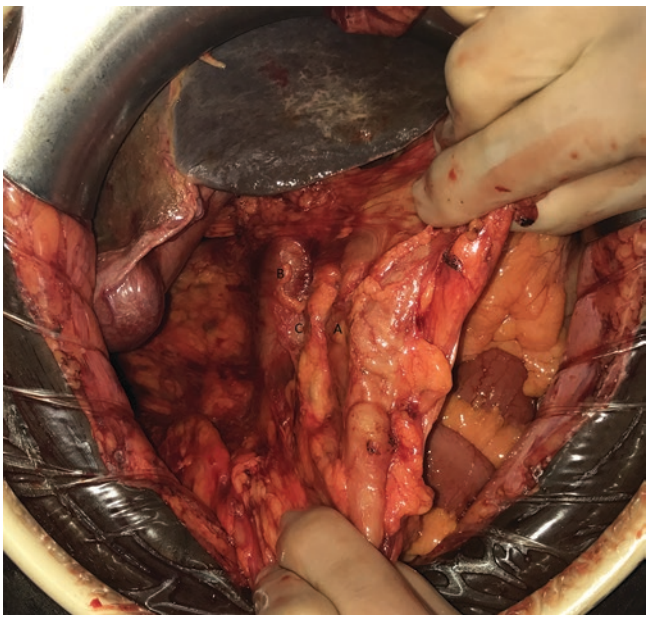


Fig. 96.4

Kocherization of the Duodenum

Perform an extensive Kocher maneuver to separate the duodenum and the head of the pancreas from the underlying inferior vena cava. It may be necessary to mobilize the hepatic flexure to gain sufficient exposure of the second portion of the duodenum. Retract the colon and small bowel inferiorly with a self-retaining or Deaver retractor.

Pull the second portion of the duodenum medially and anteriorly to allow division of the peritoneal attachments along the duodenum (Fig. 96.3). There is an avascular plane between the duodenum/head of the pancreas and the vena cava. Much of the dissection can be done bluntly or sharply with the occasional use of electrocautery to ensure meticulous hemostasis. If the mass is bulky, there may be significant inflammation, making the kocherization more challenging. Continue this kocherization medially until the left renal vein is visualized (Fig. 96.4). This extensive dissection may take effort before reaching exposure of the left renal vein, but is worth the investment in time as excellent mobilization will ease subsequent resection. Avoid excessive upward traction on the duodenum and pancreas, as it may tear the right gastroepiploic vein or the SMV.

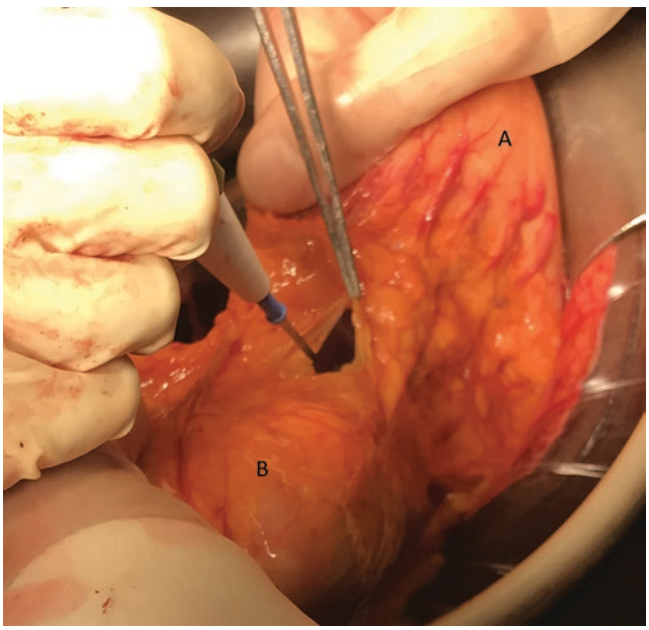


Fig. 96.5

Dissection of Portal Vein and Superior Mesenteric Vein

In order to gain exposure of the pancreas and SMV, enter the lesser sac by incising the greater omentum proximal to the transverse colon (Fig. 96.5). In order to provide the correct exposure, retract the omentum and stomach anteriorly and superiorly while retracting the transverse colon inferiorly. This will facilitate opening the potential space of the lesser sac (Fig. 96.6). The colonic mesentery can be adherent to the omentum and care must be taken not to injure the mesocolonic vessels while developing this space. Separate the omentum from the transverse colon all the way to the splenic flexure to gain full exposure of the pancreas (Fig. 96.7).

Identify the SMV by dissecting the peritoneum at the inferior aspect of the pancreas, near the neck and body. If it

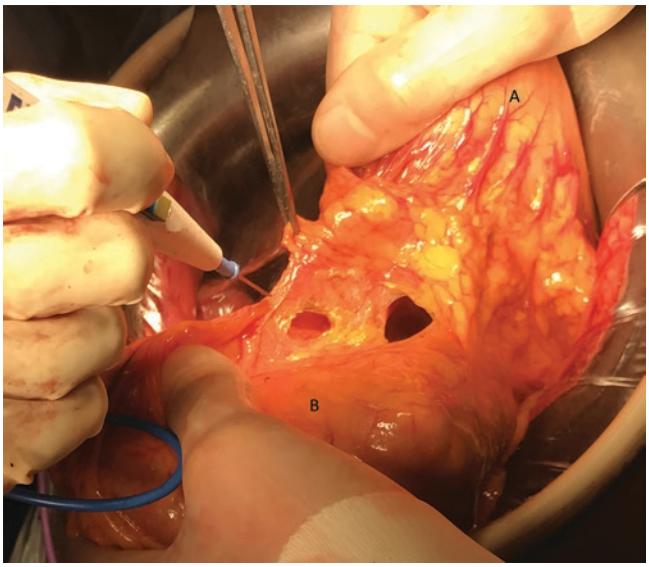


Fig. 96.6

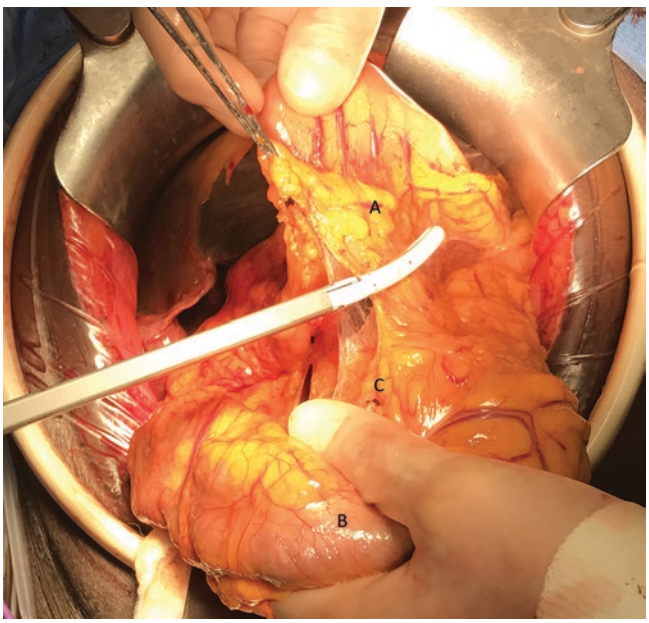


Fig. 96.7

is difficult to identify the SMV, trace the middle colic vein to its junction with the SMV (Fig. 96.8). Then follow the SMV as it courses under the pancreas. Dissect the SMV from the pancreas to begin the inferior part of the tunnel between the pancreas and the PV. During the dissection of the inferior pancreas, the gastroepiploic vessels will be encountered toward the duodenum. Dissect, tie, and ligate these early in this part of the procedure. Failure to identify these vessels and ligating them appropriately can lead to avulsion of the vessels and significant bleeding.

The tunnel is created between the anterior surface of the SMV/PV and the posterior aspect of the neck of the pancreas. There are usually no branches to the pancreas along the immediate anterior surface of the SMV/PV, allowing a clear path for dissection. Despite this, take extra care and time to ensure that there is no injury to the vessel during this dissection, as control can be difficult prior to transection of the pancreatic neck. The dissection can be done by passing a blunt tip Tonsil or Peon clamp into the plane and gently spreading. However, as this is often a blind maneuver, take extreme care not to push against any resistance encountered (Fig. 96.9). A vein retractor can be used to lift the inferior edge of the pancreas and Metzenbaum scissors can be used to gently develop the plane under direct vision as much as possible (Fig. 96.10). Note that at this point in the case, the tunnel beneath the pancreas is started, but is typically not fully completed until the superior portion of the dissection along the portal vein.

Creation of this tunnel between the SMV/PV and the pancreatic neck is the most critical part of the operation and may be challenging if there is venous invasion of the tumor. Note that the direction of the PV (and therefore the direction of the tunnel) is to the patient's right shoulder, and not directly upwards toward the head.

Cholecystectomy

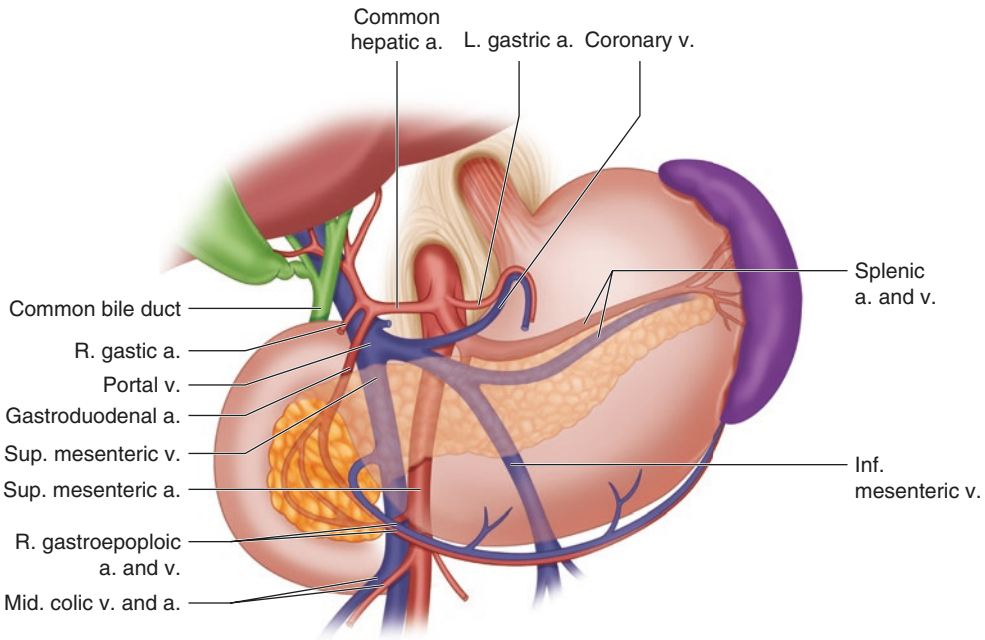
Perform a cholecystectomy in the usual manner via a top-down approach as for any open cholecystectomy. Tie the cystic artery with permanent suture (4-0 silk) proximally and clip it on the specimen prior to being divided. Similarly, tie the proximal cystic duct with a 2-0 silk prior to transection. Some surgeons prefer to keep the gall bladder in continuity with the Whipple specimen while others prefer to remove it from the field; either is acceptable.

Performing the cholecystectomy early can help with exposure of the porta hepatis and the duodenum, especially in those patients with obstruction causing gallbladder distension and those with an unfavorable body habitus. Cholecystectomy does not commit to pancreatoduodenectomy and the primary procedure can still be aborted without major sequelae if the tumor is determined to be unresectable.

Dissection of the Porta Hepatis

Prior to dissecting the porta hepatis, palpate for a replaced right hepatic artery running on the posterolateral aspect of the common bile duct (CBD). Understanding the patient's vascular anatomy prior to surgery is critical. A replaced right hepatic or an aberrant common hepatic artery originating from the SMA may be encountered at variable locations in the dissection and must be preserved.

Fig. 96.8



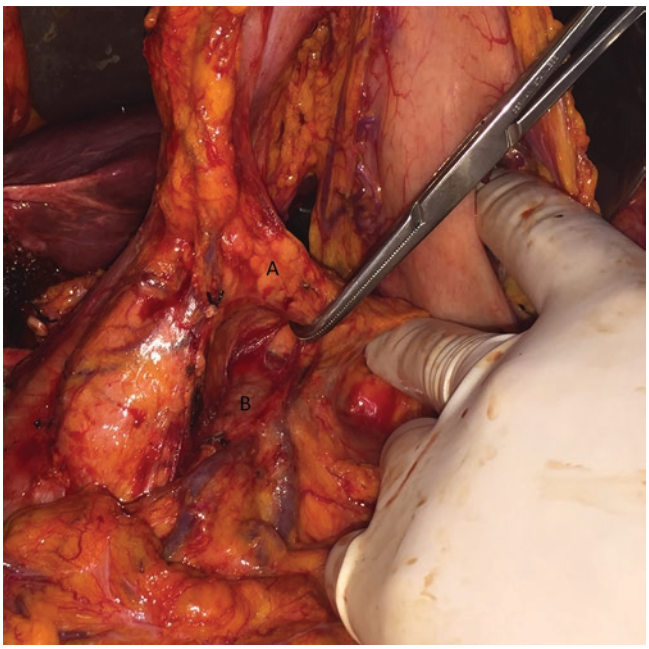


Fig. 96.9

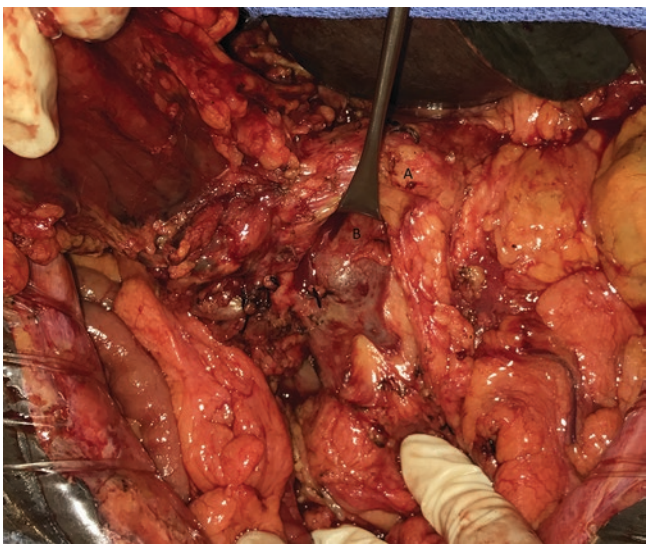


Fig. 96.10

The hepatic artery can be identified medial to the lesser curvature of the stomach after incising the filmy avascular portion of the gastrohepatic omentum. Continue to dissect the common hepatic artery to identify origins of the right gastric artery and gastroduodenal (GDA). Dissect the right gastric artery and ligate and divide it between two ligatures of 4-0 silk, allowing exposure of the GDA. Occlude the GDA and palpate the distal hepatic artery to confirm anatomy and that the GDA is not the primary arterial inflow to the liver (Fig. 96.11). Once this is confirmed, divide the GDA between two ligatures of 2-0 silk. Dissect the GDA free for about 1–2 cm to allow for a stump to be left in situ after ligation, should coil embolization be required for control of post-operative hemorrhage.

After the right gastric artery and GDA are divided, the HA can be rolled medially allowing further dissection in the porta hepatis. Incise the peritoneum over the CBD and the CBD encircled just upstream from the cystic duct insertion. For oncologic purposes, sweep any lymph nodes encountered in the porta hepatis toward the specimen so that they are removed with it.

Next, the anterior aspect of the portal vein is exposed (Fig. 96.12). This is usually immediately deep to where the

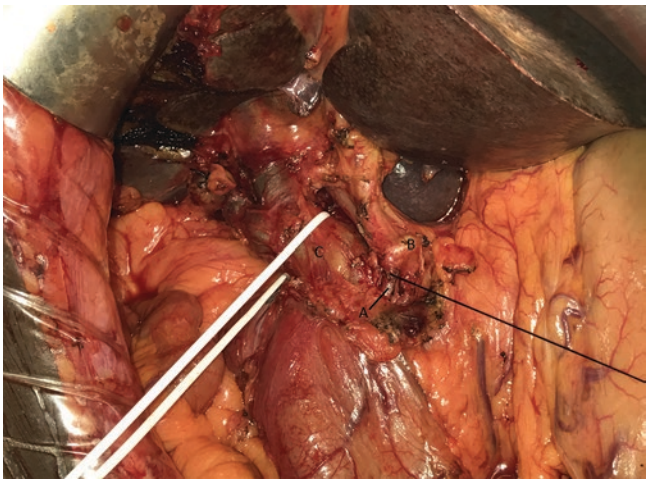


Fig. 96.11

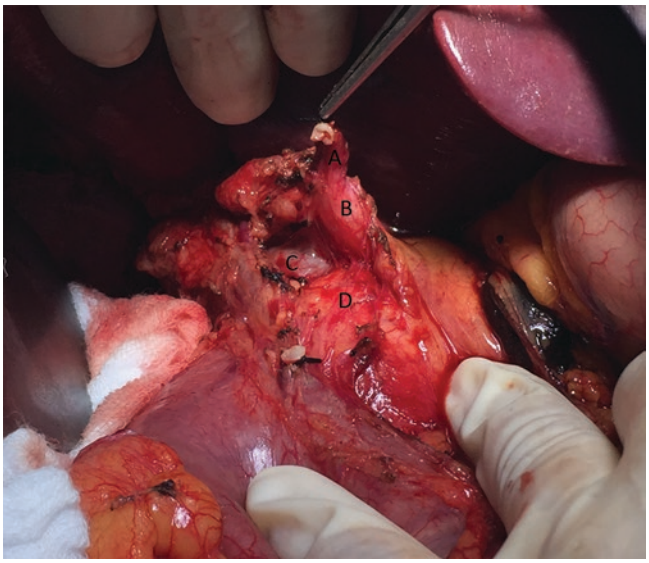


Fig. 96.12

GDA is divided, although this anatomy can be distorted with a large tumor. The presence of a large carcinoma in or near the head of the pancreas can often lead to numerous small veins superficial to the porta hepatis. Individually ligate these vessels with 4-0 silk sutures as clips in this area can be inadvertently displaced during the subsequent dissection and manipulation.

Gently free the portal vein from the overlying pancreas using a combination of blunt and sharp dissection. A blunt-tip right-angle clamp can be used to slowly and carefully develop this plane by inserting the tip between the PV and pancreas and using small gentle spreads (Fig. 96.13). Any resistance could mean there is inflammation due to, or possible invasion of, the lesion.

Complete the tunnel between the PV and the pancreas by alternately developing the plane from above and below.

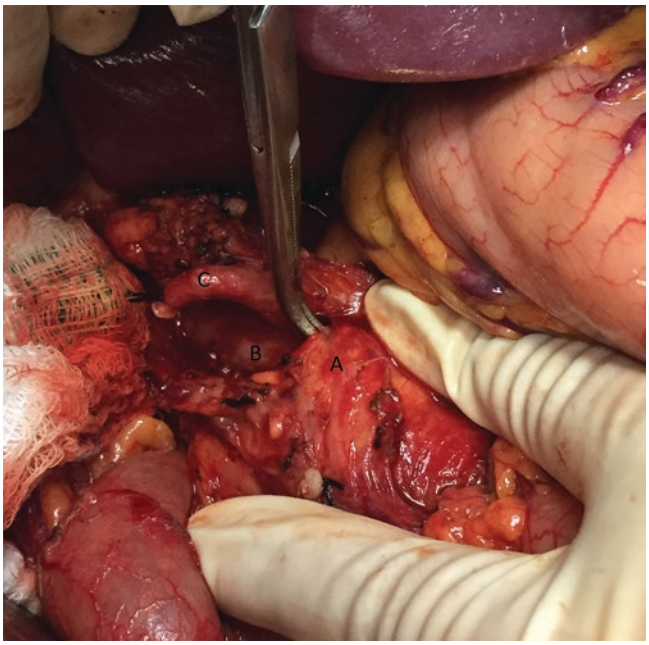


Fig. 96.13

When the tunnel is completed, pass a blunt-tip Tonsil clamp from below and use it to pull a vessel loop through the tunnel with the clamp. Use a clamp or clip to secure the vessel loop. Retract the pancreas using the vessel loop and widen the tunnel under direct vision. Once the tunnel along the PV/SMV is complete, the tumor is probably resectable, and one may now proceed with the resection (Fig. 96.14).

Transect the CBD with a fresh #15 blade, using a right-angle clamp to ensure the PV is not injured during the division of the duct. If a preoperative stent was placed, remove it and take a culture of the bile. If the patient develops a SSI or sepsis, the source is almost always from the colonized biliary system and this culture can help direct antibiotic therapy. There can be bleeding from the vessels that run along the duct in the 3′ and 9′ o'clock positions. This bleeding may be self-limiting or controlled with precise electrocautery. Alternatively, control it with 5-0 prolene sutures. Do not skeletonize the duct, as this may compromise its blood supply and increase the risk of a hepaticojejunal anastomotic leak or late stricture. If the tumor is a distal cholangiocarcinoma, consider a frozen section of the duct margin to ensure a sufficient margin has been obtained.

Antrectomy

Proceed with antrectomy or pylorus preservation as appropriate. Prior to stapling, make certain the nasogastric tube (NGT) has been pulled back and will not be caught in the staple line. Once divided, tuck the remnant stomach into the left upper quadrant to expose the body of the pancreas fully.

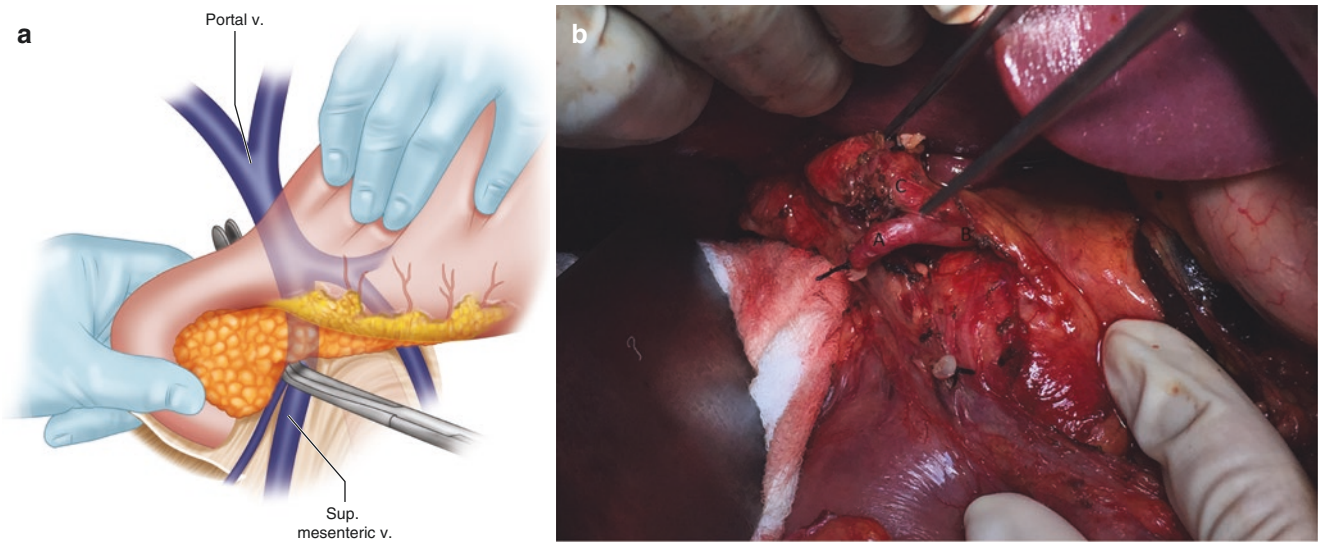


Fig. 96.14

Dissection and Division of Proximal Jejunum

Retract the transverse colon superiorly to expose the ligament of Treitz. Inspect the proximal jejunal mesenteric arcades. Select a point for jejunal transection that will allow the distal loop to reach up to the right upper quadrant without tension. This point is typically about 10 cm from the ligament of Treitz. Divide the jejunum using a 60/3.5 mm linear stapling device (GIA). Then divide the proximal jejunal mesentery using a Ligasure device. It is possible to injure the SMA during this dissection, therefore ligate the mesentery of the remaining proximal jejunum and distal duodenum as close to the bowel wall as possible. If the kocherization was sufficient, the transected proximal jejunum/distal duodenum can be passed underneath the mesenteric vessels to the right side of the patient without difficulty. Any remaining mesentery of the duodenum can now be visualized and divided (Fig. 96.15).

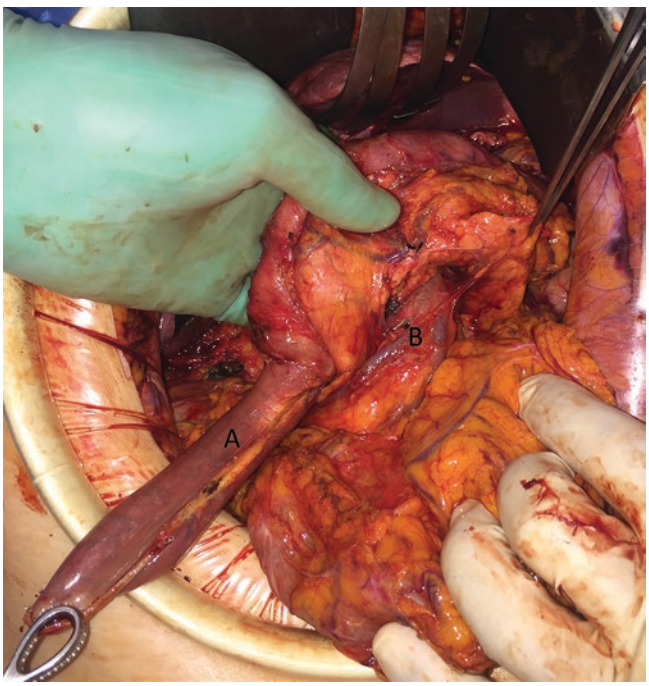


Fig. 96.15

Division of Pancreas

There are many described techniques for the transection of the pancreas. Our preferred method is passing a Satinsky clamp under the pancreas and dividing the pancreas sharply with a fresh #15 blade in one or two definite strokes to minimize trauma to the gland. Regardless of the method chosen, the most important factor is protection of the portal vein posteriorly. Take care to cut down onto the clamp and not slip off the clamp (Fig. 96.16). Alternatively, electrocautery can be used to divide the pancreas or a 30/3.5 mm linear stapler (TA) can be fired across the pancreas and the pancreas divided *to the left* of the stapling device.

When transecting the pancreas, it is helpful to cut directly perpendicular to the gland or slightly from the patient left to right to create a slight oblique edge. This will facilitate the creation of the pancreaticojejunostomy because the cut surface of the gland will be facing slightly more anteriorly than posteriorly (Fig. 96.16).

Typically, there is minor bleeding from the inferior and superior pancreaticoduodenal arteries. Some choose to place prolene sutures to help control these vessels prior to transec-

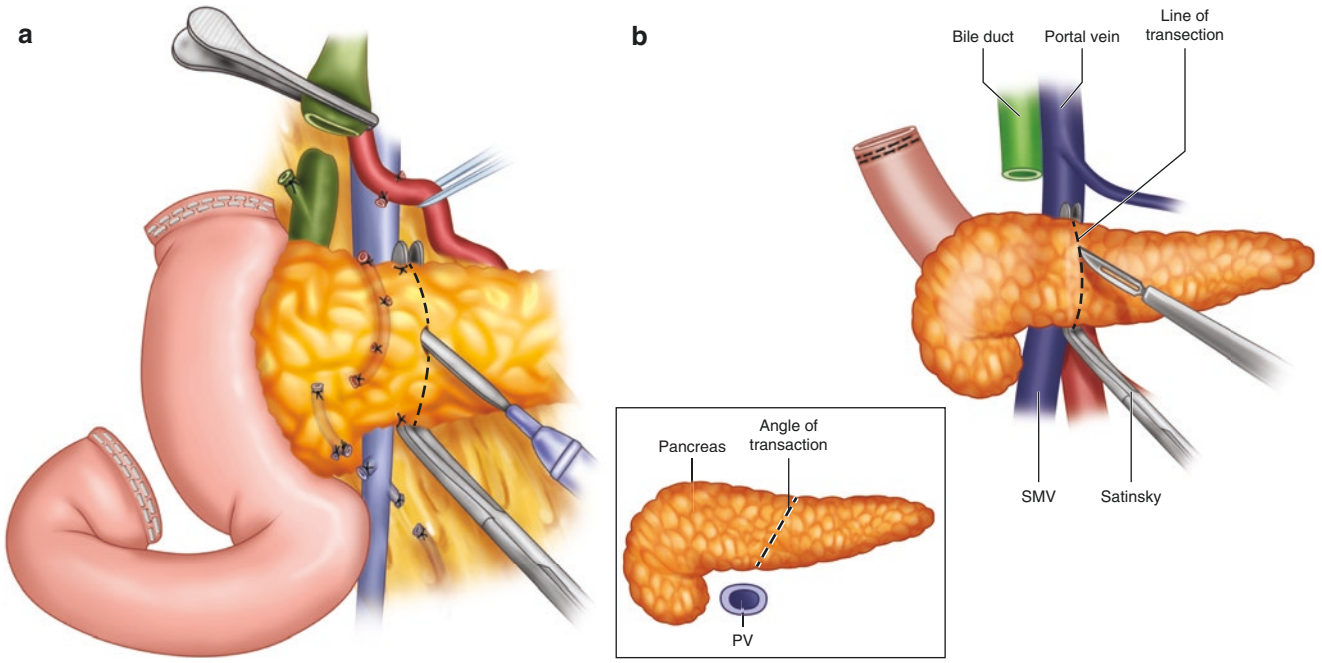


Fig. 96.16

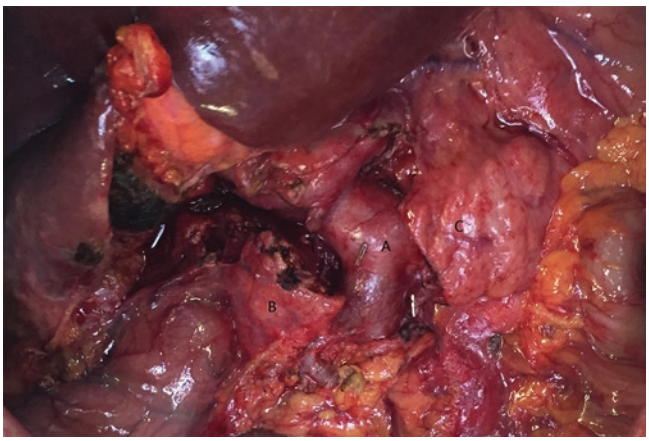


Fig. 96.17

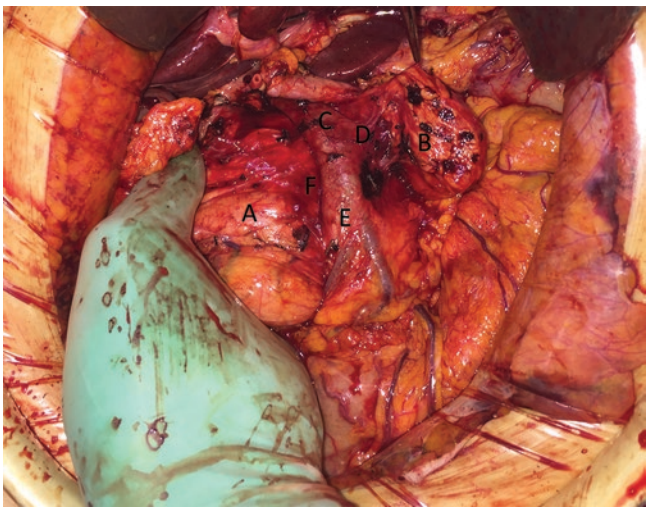


Fig. 96.18

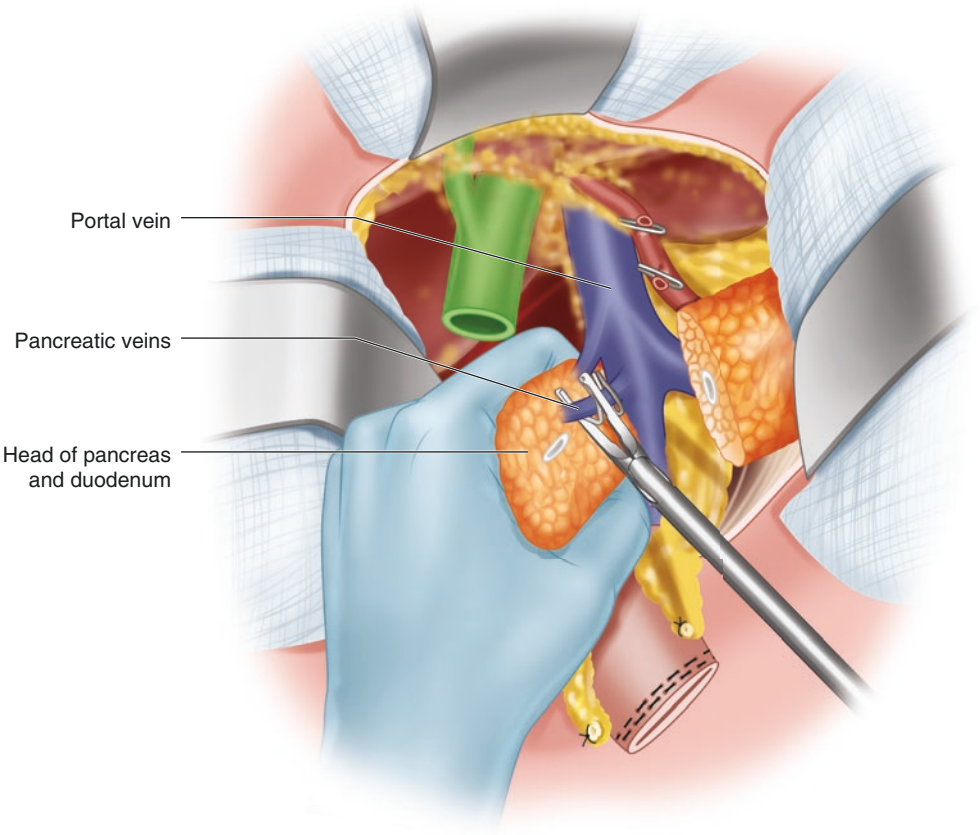
tion of the pancreas. These small bleeders can be controlled with precise electrocautery or prolene sutures, being careful not to injure or occlude the duct. At this time, a margin can be sent if there is concern regarding tumor involvement. If the margin is positive, then further pancreatic resection can be done to a negative margin (Fig. 96.17).

Dissection of Uncinate Process

At this point, the specimen should be attached only by the head and uncinate process of the pancreas. The specimen, including the cut end of pancreas, divided stomach, and the cut limb of jejunum, should be held in the surgeon's left hand and retracted to the patient's right. This will expose the anterior surface of the superior mesenteric and portal veins (Fig. 96.18). Gently dissect the specimen dissected free of the vein, ligating small branches along the way.

Once the specimen is dissected off the SMV, the dissection continues along the SMA. There are usually two or three branches from the SMA into the head of the pancreas. While retracting the specimen, identify these branches, and dissect and ligate them with 4-0 silk ties on the in situ side (and clips on the specimen to save time) (Fig. 96.19). It is important to note that in patients with a replaced right hepatic artery, it is critical to identify and protect it at its origin from the

Fig. 96.19



SMA. Once the SMA is dissected away, divide any remaining tissue with the Ligasure. Prior to transecting any tissue, it is important to confirm with either direct vision or palpation, that the SMA is not compromised. Of note, this is the margin most often compromised during pancreaticoduodenectomy. Skeletonization of the SMA border is important for an optimal oncologic resection in patients with pancreatic cancer. In patients having a Whipple for duodenal cancer or other etiologies, an option for this dissection is to use a linear stapling device to transect the uncinate process. Upon completion of this dissection, the specimen should now be completely free and passed off the field (Figs. 96.20 and 96.21).

Reconstruction Techniques

Typically, the anastomoses are completed in the following order: (1) Hepaticojejunostomy, (2) pancreaticojejunostomy, and (3) gastrojejunostomy (or duodenojejunostomy). Prior to beginning the anastomoses, inspect the surgical field and obtain good hemostasis. This is the best time to address any bleeding as once the anastomoses are completed, unnecessary manipulation and pulling on the anastomoses should be avoided.

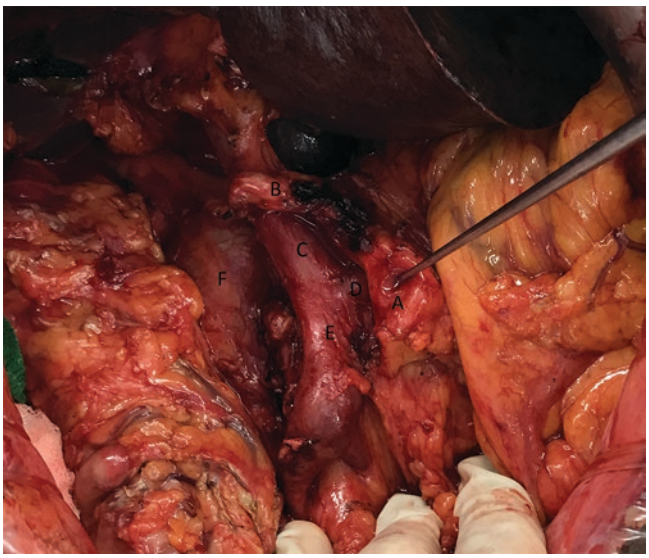


Fig. 96.20

There is a natural thin avascular area near the root of the colonic mesentery to the patient's right of the middle colic vessels. Incise this area and pass the cut end of the jejunum through. The jejunum should reach the cut bile duct and pancreatic duct and be oriented so the staple line is toward the pancreas (Fig. 96.22).

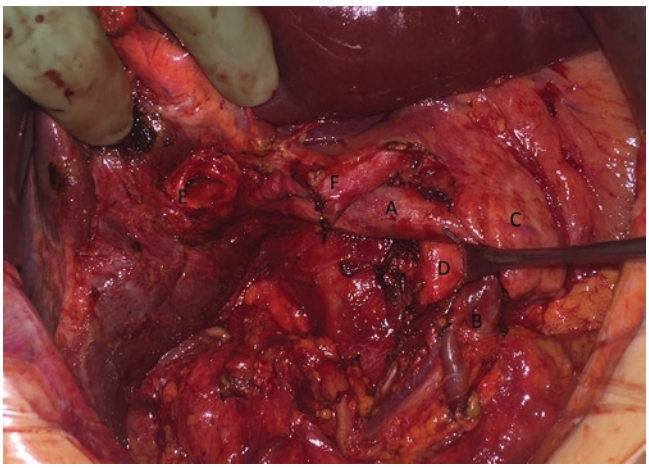


Fig. 96.21

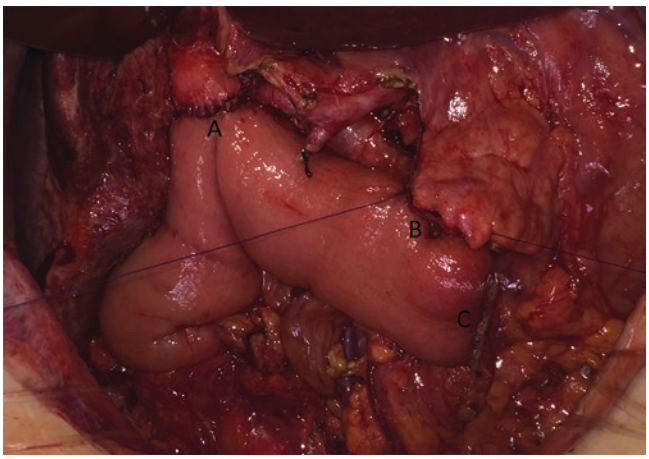


Fig. 96.22

Hepaticojejunal Anastomosis

Use Bovie electrocautery to make an incision on the antimesenteric border of the jejunum for the hepaticojejunostomy. The enterotomy should be slightly smaller than the diameter of the hepatic duct, as the enterotomy will stretch during the anastomosis. If the duct is small in size, use a 7-0 PDS stitch to secure the mucosa to the serosa of the enterotomy in four quadrants (Fig. 96.23). This will help ensure full-thickness bites of the bowel and also help align the duct and the bowel during the anastomosis. Use a double-armed 5-0 PDS to stitch the left side of the duct to the left corner of the enterotomy so that the knot is outside of the anastomosis (3 o'clock position). Complete the posterior layer of the anastamosis first using a running stitch. Then complete the anterior layer in a running fashion and the tie the two arms in the far right corner (Fig. 96.24). For ducts <5 mm in diameter, use interrupted sutures instead, starting at the 6 o'clock position and working up toward 12 o'clock.

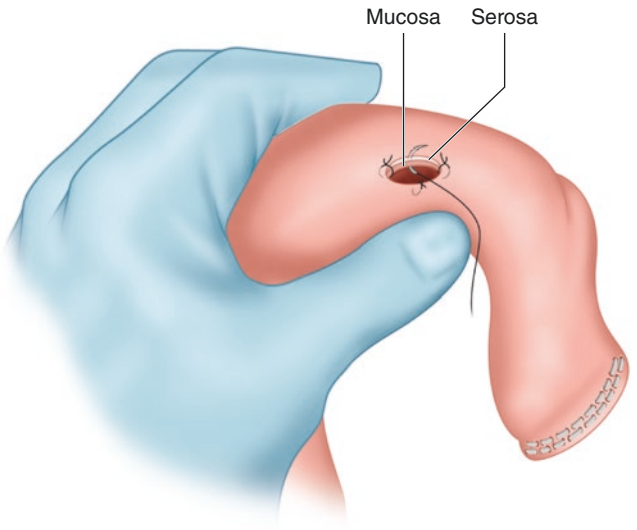


Fig. 96.23

Pancreaticojejunal Anastomosis

Elevate the cut edge of the pancreas off the underlying splenic vein. A few small branches from the pancreas to the splenic vein may require division. Free up approximately 1–2 cm of the cut end of the pancreas to facilitate the creation of the anastomosis.

Next, carefully estimate where the pancreatic duct will line up with the jejunum in order to create a tension-free anastomosis. Use Bovie electrocautery to make an incision on the antimesenteric border of the jejunum for the pancreaticojejunostomy. The size of the enterotomy should be made slightly smaller than the pancreatic duct as the enterotomy will tend to be stretched during the anastomosis. Again, use a 7-0 PDS stitch to secure the mucosa to the serosa of the enterotomy in four quadrants. This will help ensure fill thickness bites of the bowel and also help guide the anastomosis (Fig. 96.23).

There are multiple techniques described to create the pancreatic anastomosis; we describe our two preferred options.

For the *Blumgart technique*, use 2-0 Vicryl sutures on an MH1 needle to take a full thickness bite through the pancreatic parenchyma about 1 cm from the cut edge (Fig. 96.25). Take a seromuscular bite of the jejunum about 1 cm posterior from the antimesenteric aspect using the same stitch and then go back up through the pancreatic parenchyma (dorsal to ventral) right next to the original stitch. Place a clamp on the two ends of the suture, leaving the needle on the suture. Repeat this same technique to place two to three more transpancreatic stitches about 5–10 mm apart so the dorsal pancreas is lined up with the posterior aspect of the jejunum and pancreatic duct and the enterotomy are lined up for the anastomosis.

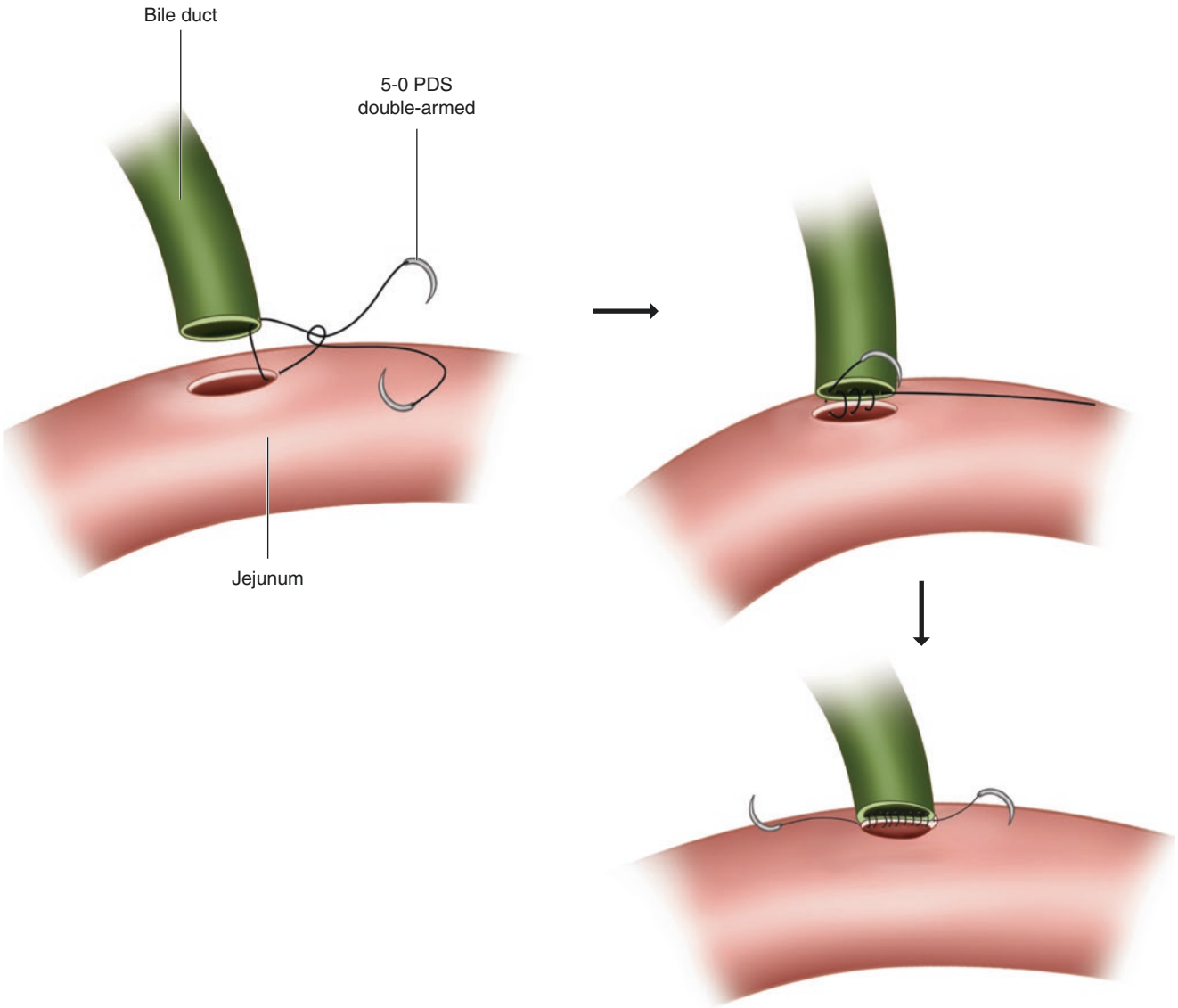


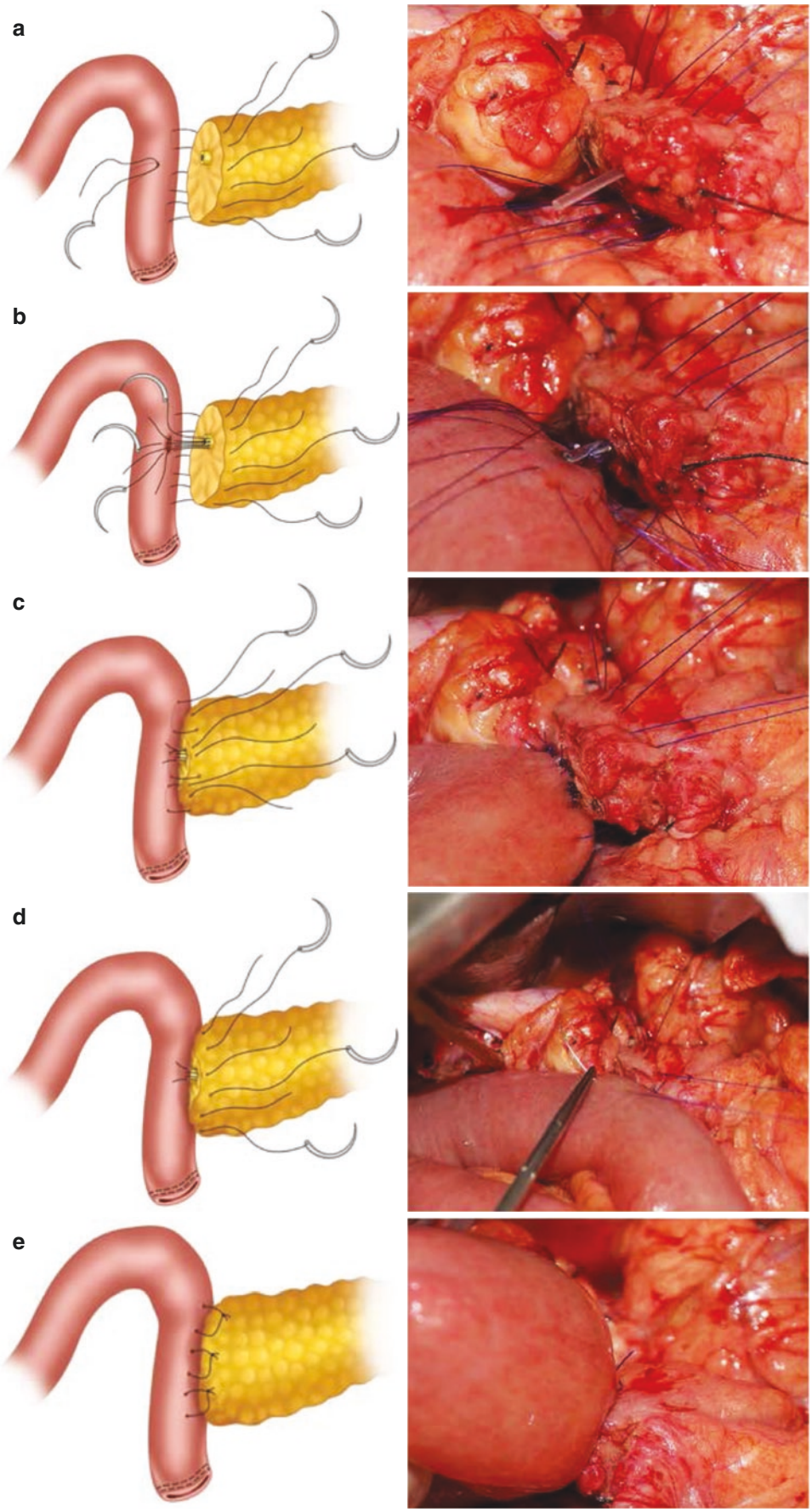
Fig. 96.24

For the duct to mucosa anastomosis, use interrupted 6-0 PDS sutures to sew the pancreatic duct to the full thickness of the jejunal wall at the enterotomy (Fig. 96.25). When completing the pancreatic duct-to-mucosa anastomosis, it can be helpful to keep the sutures double-armed, as this will provide flexibility in how to approach each individual stitch. Begin in the middle of posterior half of the anastomosis, and then work toward both corners, tying each suture as they are placed. Cut off about 4 cm of the tip of a 5-Fr pediatric feeding tube. After the posterior half of this anastomosis has been completed, place the feeding tube across the anastomosis (into the pancreatic duct and enterotomy). This will help ensure that the posterior wall is not caught while suturing the anterior aspect of the anastomosis. The "stent" is left in place to aid in the anastomosis but also serves to help keep it open in the immediate postoperative period. The tip will eventually migrate and be passed out through the bowel.

Then complete the duct-to-jejunum anastomosis with interrupted 6-0 PDS sutures, but leave these untied and place rubber-shods on these sutures. This will facilitate continued visualization of the duct and help ensure a patent anastomosis (Fig. 96.25). These sutures are tied after all the sutures have been placed to complete the anterior of the anastomosis. The previously placed 2-0 MH1 Vicryl sutures are then used to take a seromuscular stitch of the anterior jejunum mirroring the posterior stitch. These are tied carefully on the anterior wall of the jejunum, allowing the entire cut end of the pancreatic parenchyma to be covered by jejunal wall.

Alternatively, a modified *Cattell-Warren pancreaticojejunostomy* can be used for the outer layer. Using a double-

Fig. 96.25



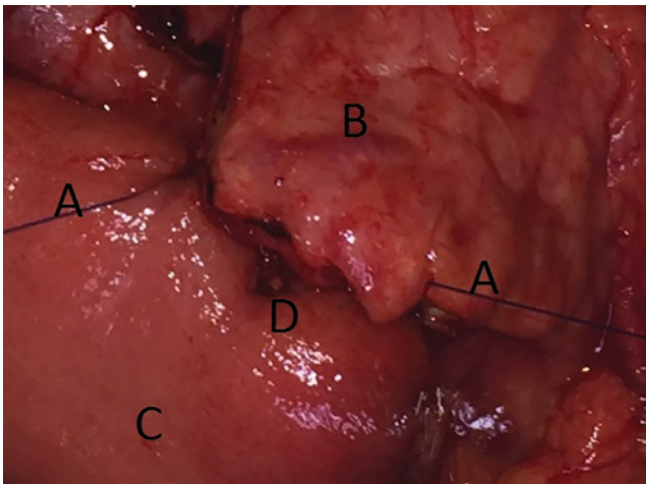


Fig. 96.26

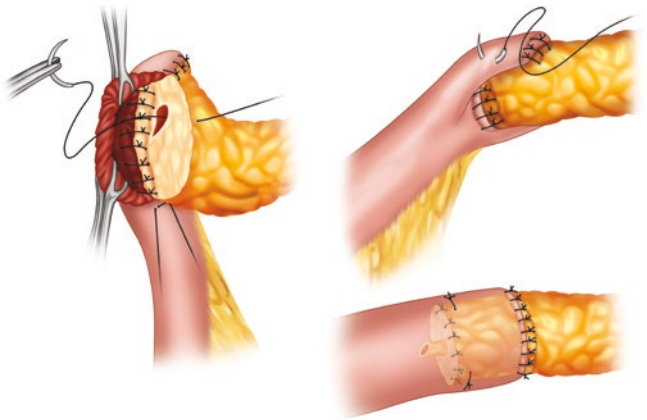


Fig. 96.27

armed 3-0 PDS or prolene, the dorsal capsule of the pancreas is sutured to the posterior aspect of the jejunum in a running fashion, making sure to align the duct with the enterotomy (Fig. 96.26). The duct-to-mucosa anastomosis is then completed using the same method described previously. The anterior aspect of the pancreas capsule-to-jejunal wall layer is completed and the two arms are tied in the corner.

Wrapping the pancreaticojejunostomy with the Falciform ligament or a tongue of omentum has been reported to decrease the leak rate.

Pancreaticojejunal Anastomosis by Invagination

An alternative method for anastomosing pancreas to jejunum is to invaginate 2–3 cm of the pancreatic stump fully into the lumen. This anastomotic method is more historical and is infrequently used, however, we have included some figures (Fig. 96.27) for a basic representation of the anastomosis. The only indication for invagination rather than a duct-to-mucosa anastomosis would be if the pancreatic duct cannot be identified at the cut end of the pancreas. Even the smallest of ducts can usually be anastomosed successfully to the mucosa of the jejunum with four to six stitches with a stent left in place.

Insertion of Drains

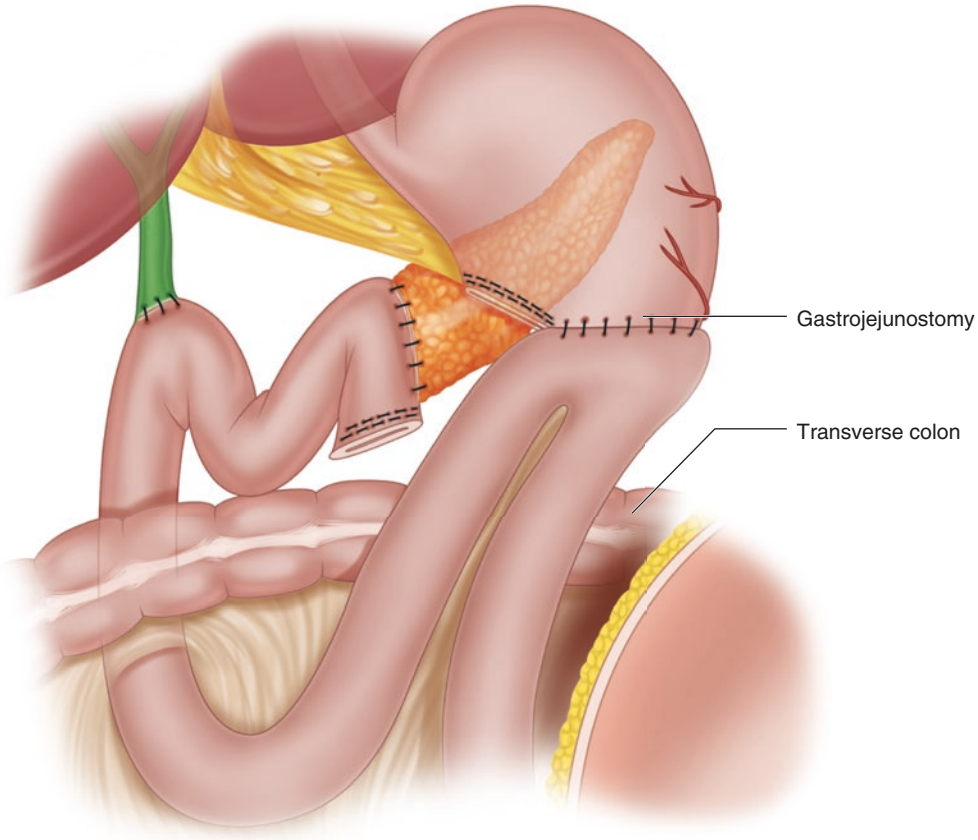
Our preference is to position the drain prior to the gastrojejunostomy, since this anastomosis will obscure access to the site. If a diagnostic laparoscopy was performed, the trocar site can be used for the drain. A 10-Fr Jackson-Pratt (JP) drain is placed posterior to the hepaticojejunostomy and pancreaticojejunostomy. Rarely, a second drain is placed anteriorly as well; usually if there is increased concern for a pancreatic leak, such as when the pancreas is soft or the duct is small in size. The drain can be placed to self-suction, to gravity, or not placed at all, based on the preference of the surgeon.

Gastrojejunostomy

The gastrojejunostomy is a two-layer anastomosis usually hand-sewn, though an anastomosis using staplers is equally as effective. Identify the proximal jejunum as it passes retrocolic and bring a loop up to the gastric remnant in an antecolic fashion. Make sure this anastomosis will be tension-free. Leave 10–20 cm between the hepaticojejunostomy and the gastric anastomosis.

The antimesenteric border of the jejunum is lined up in apposition with the staple line on the distal stomach. The entire length of the staple line can be used for the anastomosis. However, if this is very long, there may be a concern for dumping, so use of only part of the staple line is preferable. Place two silk 4-0 stay stitches to approximate the antimesenteric wall of the jejunum to the staple line on the stomach about 2 cm from the future anastomosis. Using 4-0 PDS or silk, run the back wall of the outer layer of the anastomosis, about 1 cm from the antimesenteric aspect of the jejunum and 2 cm from the staple line of the stomach. Using electrocautery, remove the staple line (or part of it) and create an enterotomy on the antimesenteric border of the jejunum that is approximately the same length as the gastrotomy. Use 4-0 PDS or 3-0 Vicryl in a running fashion to create the inner layer of the anastomosis, starting in the middle and running the stitches in each direction, ensuring full thickness bites on both the stomach and jejunum. After the posterior layer is completed, the same stitches are used to run the anterior layer from each end and tied in the mid-

Fig. 96.28



dle. Invert the mucosa with a Connell stitch. The anterior outer layer is then completed with a 4-0 PDS or silk in a running fashion. The silk stay sutures can now be removed. The anesthesiologist can now advance the nasogastric tube and the tip should be positioned just proximal to the anastomosis and the tube secured carefully to the nose. Figure 96.28 shows the anatomy after completion of all the anastomoses.

Pylorus Preservation

The important steps of the pylorus-preserving partial pancreatoduodenectomy are identical with the standard Whipple pancreatoduodenectomy except that the pylorus and 1–2 cm of duodenum are preserved.

Operative Technique

Follow the procedure as described for a standard Whipple with the following exceptions. Dissect the posterior wall of the duodenum off the head of the pancreas. Use a cutting linear stapling device (GIA) to divide the duodenum about 2 cm distal to the pylorus. Be careful not to devascularize the duodenum with overly aggressive mobilization. Anastomose the end of the duodenum to the antimesenteric side of the jejunum to form an end-to-side duodenojejunal anastomosis in an antecolic manner as you would the gastrojejunostomy. The staple line should be removed from the duodenum, leaving the duodenum wide open. Observe the cut duodenum for adequacy of bleeding. Place a layer of 4-0 interrupted silk Lembert sutures to approximate the posterior seromuscular duodenum to the jejunum just off the antimesenteric border. Make an incision in the antimesenteric border of the jejunum approximating the length of the cut end of the duodenum (Fig. 96.29). Use two 4-0 PDS or 3-0 Vicryl sutures, starting in the mid-point, to run a continuous stitch in both directions to form the posterior layer (Fig. 96.30). Then use these same sutures to complete the anterior layer and tie the stitches in the middle. The anterior outer layer is completed using 4-0 interrupted silk Lembert sutures (Fig. 96.31). Do not place the anastomosis too close to the pylorus because the close proximity of the suture line to the pylorus interferes with pyloric function and results in gastric retention.

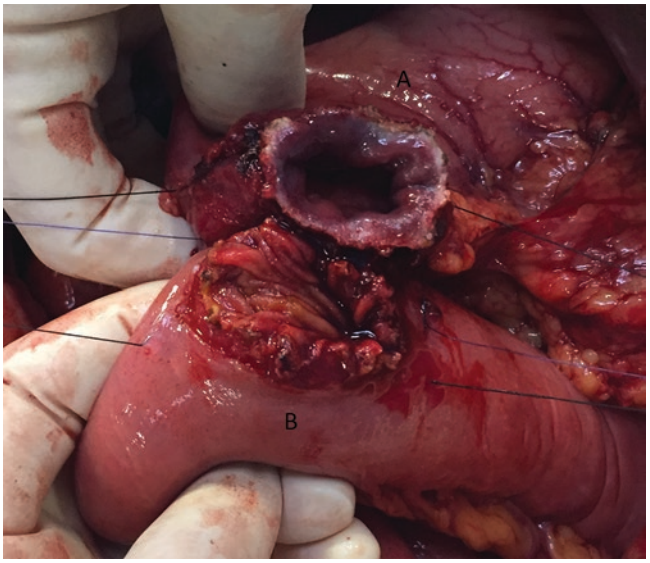


Fig. 96.29

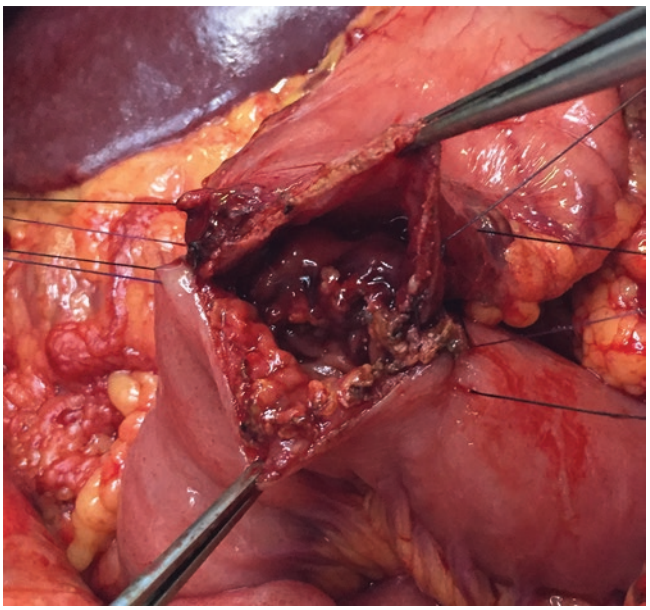


Fig. 96.30

Closure

Close the abdominal wall using #1 PDS sutures in the usual continuous fashion. The wound should be irrigated and closed with skin staples.

Postoperative Care

Perioperative antibiotics should be re-dosed based on operative room protocol. If the patient shows signs of infection postoperatively, the intraoperative bile culture can help direct antibiotic therapy.

Hemodynamic monitoring in an intensive care unit or step-down unit can be helpful, especially in older patients or those with significant co-morbidities. Intravenous fluids should be administered in sufficient quantities to ensure normal urine output. By the third postoperative day, there is frequently a brisk diuresis, at which time intravenous fluids should be limited in volume.

The patient should remain nothing-per-oral (NPO) for the first postoperative day (POD) and the nasogastric tube (NGT) can be removed unless the output is high or the patient is distended. Typically, clear liquids can be initiated on POD2 and their diet advanced as they have return of bowel function.

The Jackson-Pratt drain can typically be removed on POD7 unless there are signs of pancreatic or bilious output. If output remains high after POD5, consider sending the fluid for amylase, even if the output appears serosanguinous, as this can be a sign of a pancreatic leak.

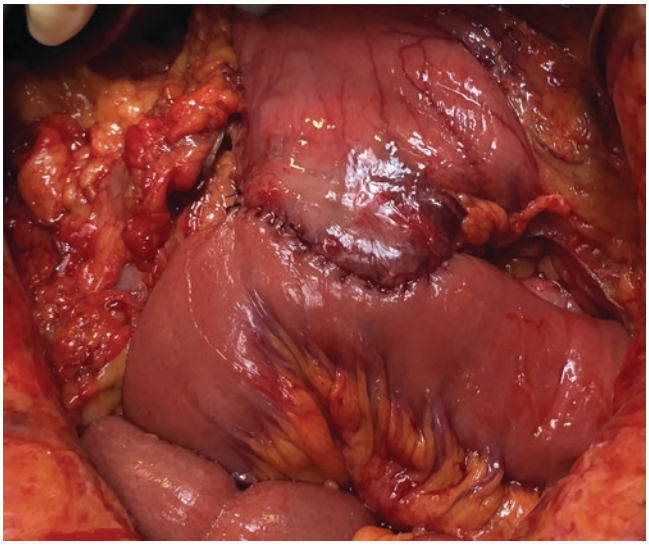


Fig. 96.31

Complications

- *Leakage from pancreatic anastomosis* Most pancreatic leaks are self-limited if the fluid is adequately evacuated by the drains placed during the procedure. A CT scan can demonstrate whether there are undrained collections that may require the placement of additional drains by interventional radiology. While some advocate for the use of total parenteral nutrition (TPN) while the anastomosis heals, most will heal while continuing to take normal oral

intake. Operative intervention is rarely, if ever, needed for a pancreatic leak and should only be done when non-operative management fails. Re-laparotomy can lead to further disruption of the pancreatic and biliary anastomoses and cause more harm than good. If initial attempts to control the leak fail and the patient is doing poorly, a last resort can be to remove the remaining pancreas.

- *Postoperative Sepsis* Sepsis and hemorrhage are evidence of leakage from the pancreaticojejunal anastomosis unless proven otherwise. Use of broad-spectrum antibiotics and fluid resuscitation are mainstays of therapy. All undrained collections should be drained by percutaneous radiological guided drainage.
- *Postoperative Hemorrhage* A GDA blowout, classically heralded by a sentinel bleed seen in the Jackson-Pratt (JP) drain or hematemesis is pathognomonic of a pancreatic leak. This complication must be recognized at the time of the first bleed and should prompt angiography and embolization by interventional radiology. Failure to recognize this event and initiate early intervention often leads to catastrophic outcomes.
- *Delayed Gastric Emptying* This complication can be unpredictable in onset, though many feel that it is the sequelae of an unrecognized pancreatic leak. Duration may be a few days, which may necessitate placement of an NGT for decompression. Prolonged delayed gastric emptying will necessitate continued feeding through the jejunostomy tube, if placed, or TPN. Although there are few effective therapies, fortunately the course is usually self-limited.

Further Reading

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