Robotic Pylorus-Preserving Pancreaticoduodenectomy

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Introduction

The application and adoption of minimally invasive techniques in hepatopancreaticobiliary (HPB) surgery have been much slower when compared to other surgical disciplines such as urology, gynecology, colorectal, and bariatric surgery. Notably, HPB operations are uncommon, and they involve unusual complexity, with relatively high risk and "many moving parts." The complexity of surgical steps undertaken during pancreaticoduodenectomy includes the precise dissection along major mesenteric vessels and reconstruction of biliary, pancreatic, and enteric anastomoses. To date, there have been just more than a handful of centers in the world that have accumulated a notable experience with laparoscopic pancreaticoduodenectomy [1–9].

The advent and development of robotic platforms, such as the da Vinci Xi® system (Intuitive Surgical, Sunnyvale, CA, USA), provide an avenue to obtain MIS proficiency due to the robotic features that overcome many of laparoscopy's shortcomings of visualization of the surgical field and manipulation of tissue. The da Vinci Xi® system, through EndoWrist™ motion technology, offers instruments that mimic the natural dexterity of the human hand, with seven degrees of freedom, more than that of the human wrist. The vision system offers the first immersive vision system, which is aided by the 3D laparoscope. The surgeon console synchronizes two images produced by optics at the tip of the laparoscope to produce a higher resolution and a more natural view of the operating field. Furthermore, the robotic system provides surgeons with improved ergonomics and improved manipulation by reducing physiologic tremor and scaling movements into smaller, more precise maneuverings. For these reasons, enthusiasm for minimally invasive pancreaticoduodenectomy has entered a new phase, especially among pancreatic surgeons at high-volume centers worldwide.

Zureikat et al. reported similar perioperative outcomes achieved by robotic pancreaticoduodenectomy when compared to open pancreaticoduodenectomy in a recent multi-institutional study consisting of 1028 patients [10]. On multivariate analysis, the robotic approach was associated with longer operative times but reduced operative blood loss and reduced rate of major complications. Ninety-day mortality, clinically relevant postoperative pancreatic fistula, infection rate, postoperative length of stay, and 90-day readmission rate were comparable to the open approach. In a subset analysis of 522 patients who underwent pancreaticoduodenectomy for pancreatic ductal adenocarcinoma, operative approach was not an independent predictor of margin status or suboptimal lymphadenectomy (<12 lymph nodes harvested).

There have been several variations of surgical techniques among centers that offer robotic pancreaticoduodenectomy. Fully robotic, hand-assisted, and hybrid laparoscopic-robotic techniques (laparoscopic resection and robotic reconstruction) have been developed and described [1, 11–16]. Reconstruction techniques, including "classical" versus pylorus-preserving pancreaticoduodenectomy, are also varied among centers and surgeons [1, 10]. Our group has a tremendous experience with both pancreaticoduodenectomy, laparoscopic operations, advanced laparoendoscopic single-site (LESS) foregut operations, and robotic surgery [17–22]. Our technique for pancreaticoduodenectomy is an outgrowth of our experience; herein, we describe our current technique for undertaking robotic pylorus-preserving pancreaticoduodenectomy. It must be realized that robotic pancreaticoduodenectomy is still in its relative infancy, and the technique and its application will continue to evolve in the years to come.

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Y. Fong et al. (eds.), *The SAGES Atlas of Robotic Surgery*, https://doi.org/10.1007/978-3-319-91045-1_28

Indications and Contraindications

Indications

- Malignant pancreatic lesions of the head, uncinate process, and/or neck of the pancreas, including pancreatic ductal adenocarcinoma, pancreatic islet cell carcinoma, malignant intraductal papillary mucinous neoplasm (IPMN), peri-ampullary adenocarcinoma, cholangiocarcinoma, and duodenal carcinoma

Contraindications

- Patients with locally advanced disease
- Patients with metastatic disease
- Patients with presumed significant intraperitoneal adhesions from multiple prior open abdominal operations
- Patients who underwent neoadjuvant chemotherapy and/or radiation therapy for locally advanced disease now with resectable disease that requires major vascular resection and reconstruction

Preparation and Operative Strategy

- Computed tomography (CT) of the chest, abdomen, and pelvis, 1-mm thin-cut high-quality triphasic with oral and IV contrast (pancreatic protocol)—for the diagnosis and staging of malignant lesions
  - We also utilize Surgical Planner™ (Surgical Theater LLC, Mayfield Village, OH) to reconstruct patient-specific 3D models, which is helpful to evaluate for resectability, surgical planning, as well as patient and family education.
- MRCP—to delineate the pancreatic and biliary ducts (not always necessary)
- Comprehensive laboratory examination (i.e., CA 19–9 tumor marker levels, etc.)
- Endoscopic ultrasound (EUS) and fine-needle aspiration (FNA)—preoperative tissue biopsy for histologic diagnosis and staging
- Endoscopic retrograde cholangiopancreatography (ERCP)—with the placement of an intraductal stent when necessary (i.e., obstruction of the distal common bile duct with hyperbilirubinemia)
- Risk analysis —cardiac, pulmonary, liver, and kidney function
- Enhanced recovery after surgery (ERAS) pathway
  - Patient education and nutritional status

Our indications for conversion to "open" pancreaticoduodenectomy include, but are not limited to:

1. Failure to progress for greater than 20 min for whatever reason
2. Significant intraoperative bleeding or uncontrolled bleeding
3. Intolerance to carbon dioxide pneumoperitoneum
4. Major vascular invasion
5. Any factors that promote an R1 resection
6. Excess difficulties to complete safe biliary, pancreatic, or enteral reconstruction

We follow an enhanced recovery after surgery (ERAS) protocol for robotic pancreaticoduodenectomy. Patients are given preoperative education of the protocol by a team member in clinic after a plan to operate is made. The multidisciplinary team of surgeons, physician extenders, perioperative nursing staffs, residents, fellows, and anesthesiologists (and their certified registered nurse anesthetists) must all be familiar with the ERAS protocol. Briefly, preoperatively, the patient agrees to smoking/alcohol cessation, a new preoperative weight loss and diet regiment, exercise, diabetes education classes, preoperative use of incentive spirometry, and the intake of Impact Advanced Recovery® (Nestle HealthCare Nutrition, Florham Park, NJ) (a nutritional drink taken three times a day for 5 days and ending the night before the operation to boost their immune system).

Additionally, patients meet with members of the anesthesiology team to discuss their perioperative analgesia management plan (i.e., intrathecal injection of 10 cc of Duramorph® prior to induction, oral Celebrex/gabapentin, and IV Tylenol postoperatively). Alvimopan is administered preoperatively, and it is continued twice daily for 7 days, as needed, for perioperative postoperative nausea and vomiting control. It is our opinion that diligent preoperative education (by all members of the multidisciplinary team) of the patient on what to expect has led to early recovery and increased patient satisfaction. With this ERAS plan, we have been able to reduce our length of stay after robotic pancreaticoduodenectomy to 3–5 days.

Operating Room Setup

The patient is placed in the supine position on the operating table. Compression stockings and sequential compression devices (SCD) are used in all patients to prevent deep vein thrombosis (DVT). After general endotracheal anesthesia is established, a nasogastric tube and a Foley catheter are placed. Both arms are extended and all pressure points are padded. The patient's abdomen is widely prepped with alcohol, and a Betadine-impregnated plastic drape is applied. The surgical table is then positioned in reverse Trendelenburg position with a slight left lateral tilt. The da Vinci Xi® robotic system is docked with the boom coming over the patient's right shoulder. The bedside surgeon stands on the patient's right, and the scrub tech stands to the patient's left. This arrangement enables easy access to the robotic arms for instrument exchange. Two surgeon consoles are placed in such a way that the surgeon at the console has a direct visualization of the patient. We utilize dual consoles for the education and training of fellows and residents. Intraoperatively, the 3D image system is utilized for surgical navigation. The Surgical Navigation Advanced Platform™ (SNAP, Surgical Theater LLC, Mayfield Village, OH) images are displayed on a portable monitor and placed next to the surgeon console for easy reference by all the team members during the operation.

Operative Steps

Step 1. Operating Room Setup (Fig. 28.1) and Port Placement

Prior to making the incision, approximately 5–8 cc of 0.25% Marcaine™ (AstraZeneca, Wilmington, DE) with epinephrine (1:1000) is injected into the umbilicus and all robotic port sites for local anesthesia. We believe this helps to decrease postoperative pain. The abdomen is entered via 8-mm incision in the umbilicus, and pneumoperitoneum is established (up to 15 mmHg). After diagnostic laparoscopy, without notable findings, three 8-mm robotic trocars, an Advanced Access Gelport® (Applied Medical, Rancho Santa

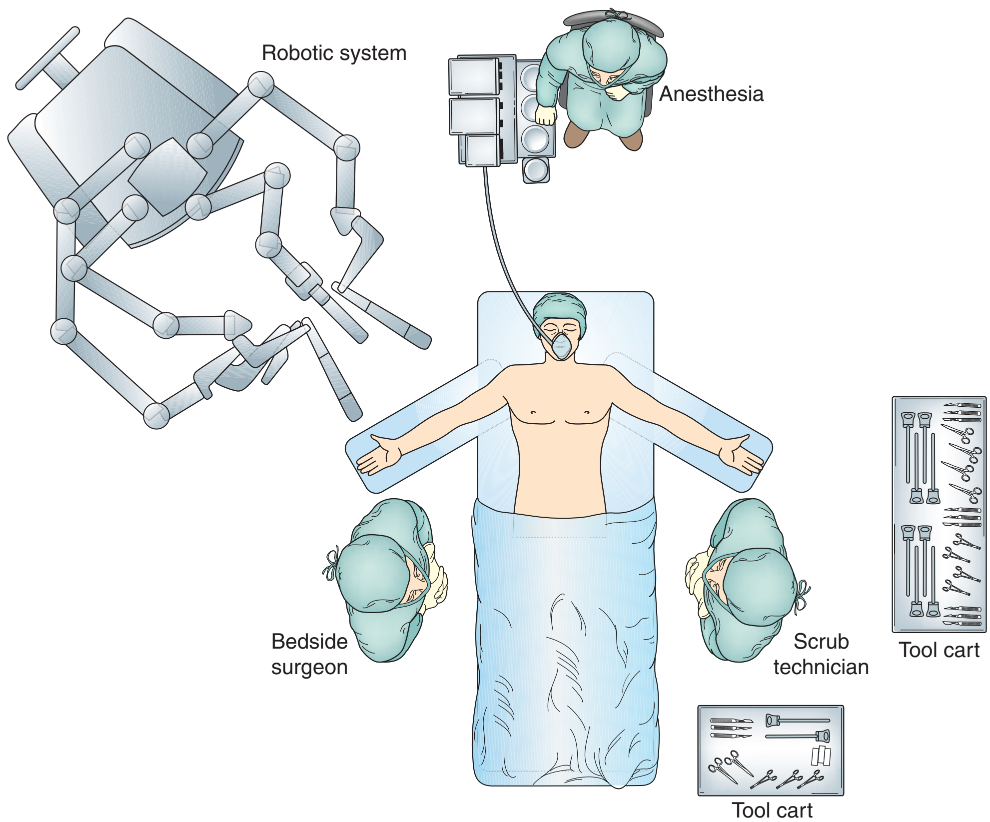


Fig. 28.1 Operating room setup

Margarita, CA), and one 5-mm AirSeal® Access Port (ConMed Inc., Utica, NY) are then placed under laparoscopic visualization. The placement site for each trocar is very important. The liver retractor is placed via the right upper quadrant AirSeal® port and secured to the surgical drape using Kocher clamps. The da Vinci Xi® robotic system is brought from the patient's right shoulder, and it is docked with the bed in the reverse Trendelenburg position with a slight left lateral tilt.

- Trocar placement (Fig. 28.2):
  - At the right midclavicular line, same level as the umbilicus, for 8-mm robotic trocar (robotic arm # 1)
  - At the umbilicus: 8-mm trocar for the robotic camera (robotic arm # 2)
  - At the left midclavicular line, slightly above the level of the umbilicus, for 8-mm robotic trocar (robotic arm # 3)
  - At the left anterior axillary line, midway between the umbilicus and the costal margin, for 8-mm robotic trocar (robotic arm # 4)
  - At the right anterior axillary line about 4 cm caudal to the costal margin for the AirSeal® Access Port
  - Between the midclavicular line and the umbilicus caudal to the umbilicus for Advanced Access Gelport® (not interfering with robotic arm # 1)

Step 2. Porta Hepatis Dissection

Robotic arm # 1—Fenestrated bipolar device.
Robotic arm # 2—Camera.
Robotic arm # 3—Hook cautery.
Robotic arm # 4—Atraumatic bowel grasper.
The Advanced Access Gelport® is used for a suctioning device and atraumatic graspers utilized by bedside surgeon.
The AirSeal® Access Port for liver retractor.

The robotic camera remains in robotic arm # 2 until we begin closing trocar incisions. The gastrohepatic ligament is opened (Fig. 28.3) in a stellate fashion utilizing robotic hook cautery. The common hepatic artery is identified, despite the characteristic overlying lymph node, and followed distally toward the porta hepatis. The common hepatic artery lymph node (Fig. 28.4a, Station VIIIa node) is removed and sent to pathology for frozen section examination if it is substantial or suspicious. The gastroduodenal artery (GDA) is identified and circumferentially dissected prior to placement of two (or three) Hem-o-lok clips both proximally and distally. A thorough review of a triphasic CT scan and/or 3D imaging preoperatively is mandatory to rule out the presence of an accessory or replaced right hepatic artery, which is anticipated in this location. In our experience, the use of 3D virtual imaging has helped immensely in this regard.

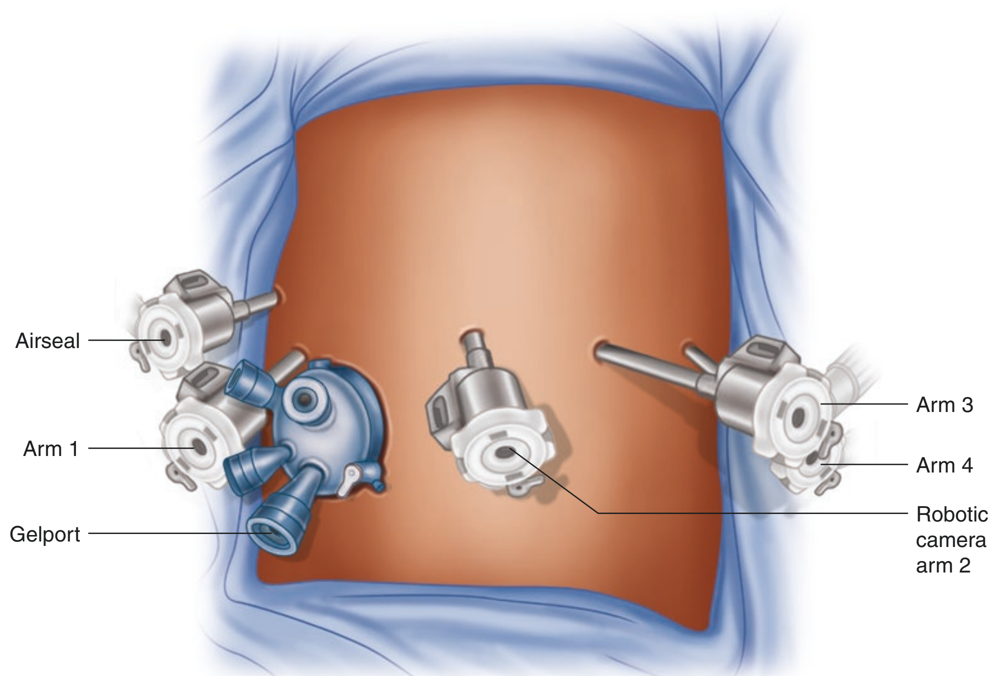


Fig. 28.2 Trocar/port placement

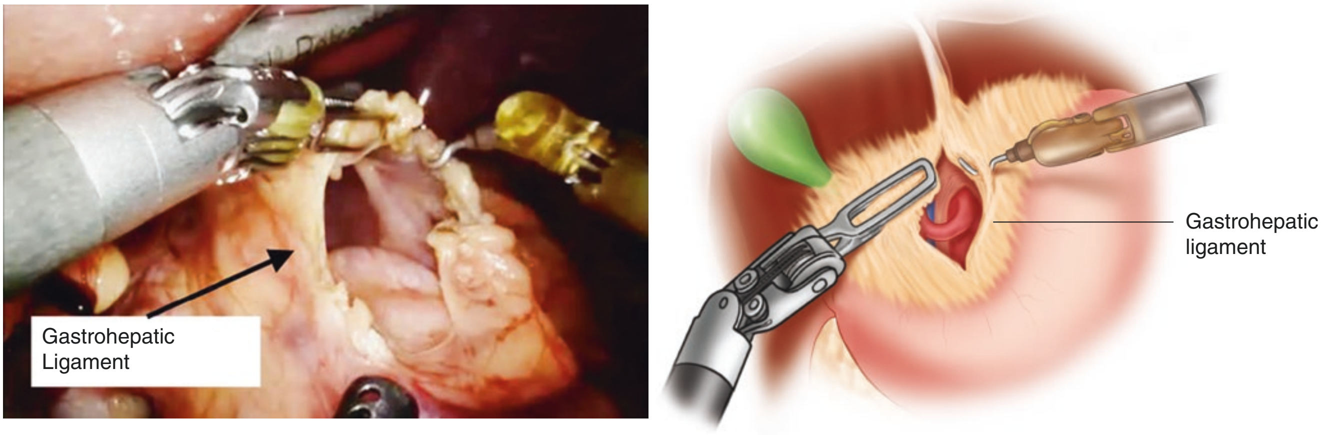


Fig. 28.3 Porta hepatis dissection, opening of the gastrohepatic ligament

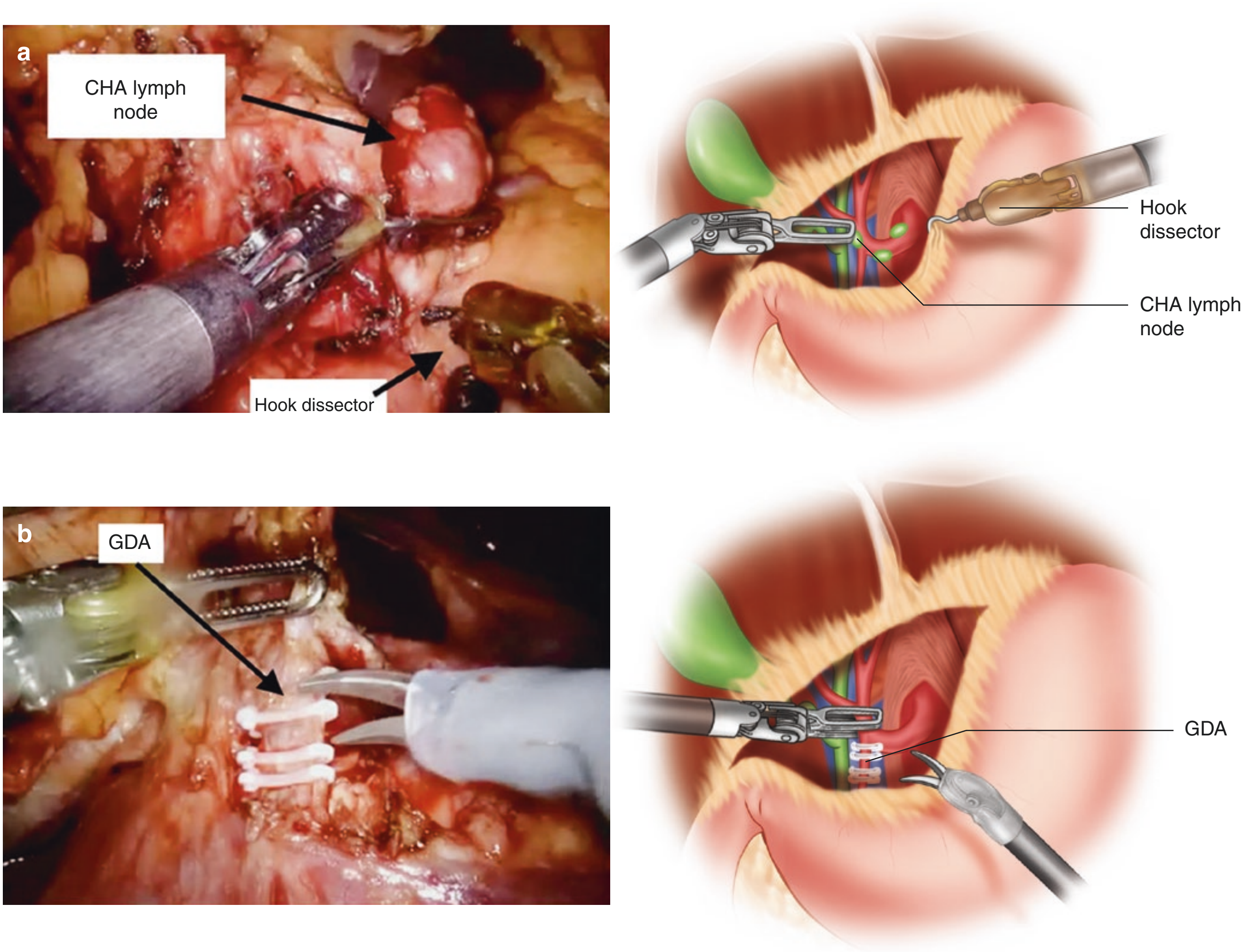


Fig. 28.4 (**a**) Dissection and removal of the common hepatic artery (CHA) lymph node. (**b**) Ligation and transection of the gastroduodenal artery (GDA)

Prior to division, the GDA is routinely test-clamped, and the pulse in the hepatic artery is visually assessed to confirm the artery being divided is not a replaced hepatic artery and to exclude a significant celiac artery stenosis. Once the GDA has been divided using robotic scissors (Fig. 28.4b), the portal vein, which is located posteriorly, comes into view with a bit of dissection dorsal to and medial to the GDA. The common hepatic duct is circumferentially dissected proximal to the cystic duct (before or after undertaking cholecystectomy). The distal common bile duct is identified and separated away from the portal vein by developing an avascular plane between them. The common bile duct lymph nodes, which are located along the right posterolateral aspect of the duct, are carefully taken with the specimen with hook cautery. The dissection is carried down the distal common bile duct (Fig. 28.5).

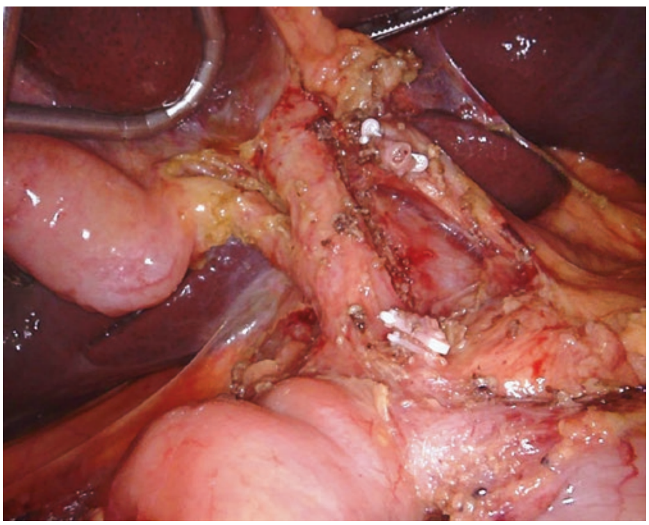


Fig. 28.5 Dissection carried down the distal common bile duct

Step 3. Kocher Maneuver

Robotic arm # 1—Fenestrated bipolar device.
Robotic arm # 2—Camera.
Robotic arm # 3—Hook cautery.
Robotic arm # 4—Atraumatic bowel grasper.

Because the nature of any written report does not allow for simultaneous activities, it is important for us to note that a Kocher maneuver may be undertaken first in the operation. With adequate anterosuperior retraction of the liver, the hepatic flexure of the colon is mobilized caudally as needed. The c-loop of the duodenum is exposed and widely mobilized, working proximal to distal along the lateral edge of the duodenum. The duodenum is grasped with an atraumatic bowel grasper in the robotic arm # 4 and retracted ventrally and, especially, to the left, with great care to avoid injury to the duodenum. The dissection continues until the left renal vein is easily identified and the ligament of Treitz is divided (Fig. 28.6). Next, the proximal jejunum is exposed. The jejunum is then delivered to the right of the superior mesenteric vein and divided with a robotic stapling device. The jejunum should be placed so that it can easily be retrieved later.

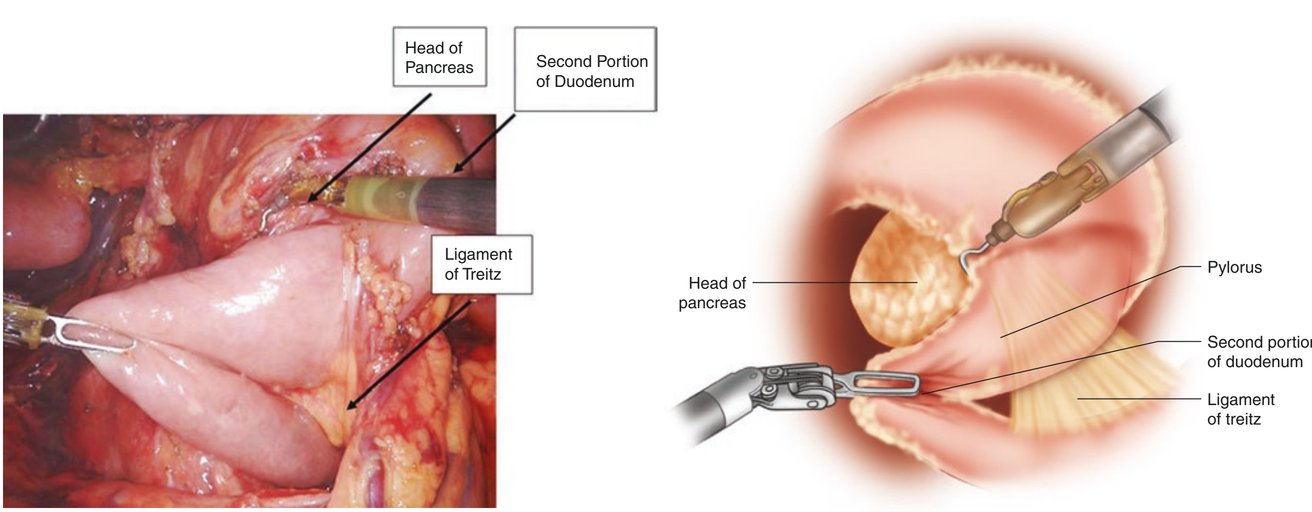


Fig. 28.6 Kocherization of duodenum

Step 4. Pancreatic Exposure

Robotic arm # 1—Fenestrated bipolar device.
Robotic arm # 2—Camera.
Robotic arm # 3—Vessel sealer (alternating with hook cautery).
Robotic arm # 4—Atraumatic bowel grasper.

We begin to divide the gastrocolic omentum, while the stomach is reflected in the cephalad direction. The gastrocolic omentum is opened somewhere near the midpoint along the greater curve of the stomach, probably closer to the pylorus. This exposure places the right gastroepiploic vein at a near-right angle to the superior mesenteric vein, to facilitate later clipping and division. As the omentum is opened, the pancreas comes into view. The inferior border of the pancreas is identified and dissected along utilizing hook cautery going carefully toward the superior mesenteric vein; in general, we like to dissect away from critical vessels to avoid injury. The right gastroepiploic vein may be double-clipped and divided at this time. In unusual circumstances of morbidly obese patients or when a significant amount of adipose tissue is encountered in this location, a robotic ultrasound device can be used to help identify the exact location of the superior mesenteric vein.

Once the superior mesenteric vein is identified, the dissection is carried along its ventral surface going cephalad (Fig. 28.7). A tunnel behind the neck of the pancreas is carefully developed using robotic hook cautery while gently elevating the pancreas anteriorly using a fenestrated bipolar grasper and an atraumatic bowel grasper. A suction device placed through the gel port pushes gently down on the portal vein to keep it from harm's way. Once the tunnel is developed, we determine that the tumor mass is resectable with "clean" margins, and, if resection is the plan, we proceed with pancreatic transection.

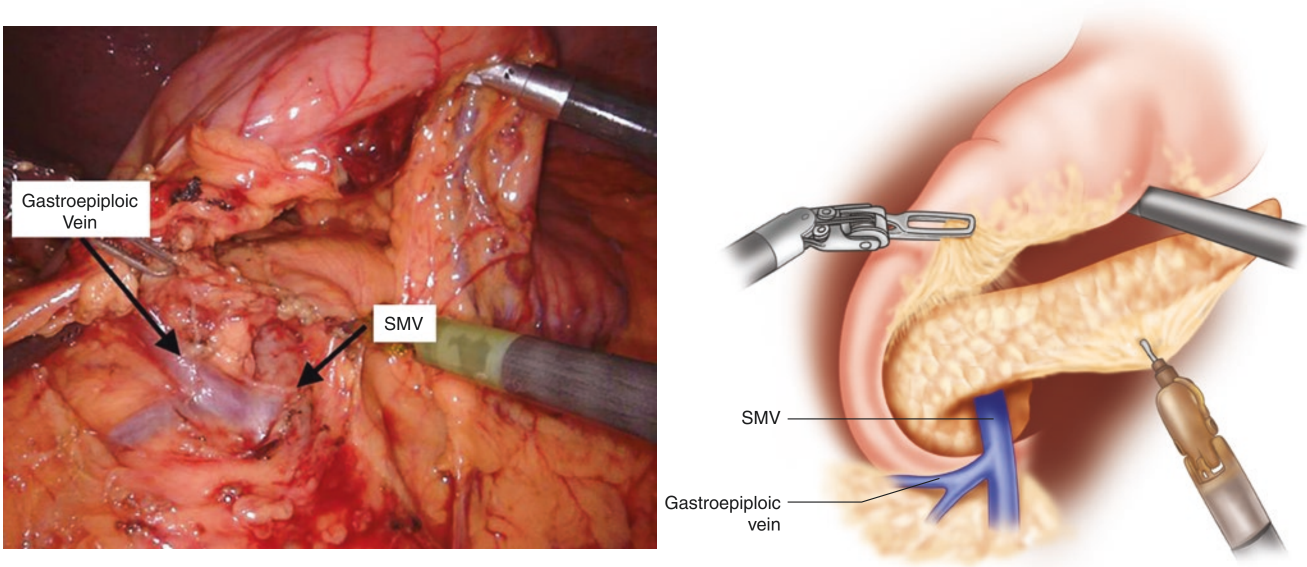


Fig. 28.7 Pancreatic exposure and transection of the neck of the pancreas

Step 5. Transection of the First Portion of Duodenum

Robotic arm # 1—Fenestrated bipolar device.
Robotic arm # 2—Camera.
Robotic arm # 3—Vessel sealer.
Robotic arm # 4—Atraumatic bowel grasper.

The gastrocolic omentum is further divided while avoiding the transverse mesocolon. Transection of the right gastroepiploic vessels occurs during this dissection. The distal stomach, pylorus, and first portion of duodenum are mobilized. The identification of the pylorus is aided by the recognition of the vein of Mayo. A point of transection for a stapling device is chosen approximately 2 cm distal to the pylorus (Fig. 28.8), but we work to get as much length along the duodenum as possible; dusky duodenum can always be trimmed back later. After transection, the stomach and duodenum are then deflected to the left upper quadrant, and the neck of the pancreas is now clearly visualized.

Step 6. Pancreatic Transection

Robotic arm # 1—Fenestrated bipolar device.
Robotic arm # 2—Camera.
Robotic arm # 3—Vessel sealer (alternating with hook cautery).
Robotic arm # 4—Atraumatic bowel grasper.

The pancreatic parenchyma is divided using robotic hook cautery (Fig. 28.9) or bipolar scissors. A laparoscopic suctioning device is introduced into the Advanced Access Gelport®. The suctioning device is utilized for suctioning and retracting tissue. Hemostasis must be obtained as the pancreatic transection advances, because excessive bleeding in this area can obscure the view of the operative field very quickly. Most of the pancreatic transection is undertaken with the hook cautery; the main pancreatic duct is identified. The pancreatic duct is then sharply divided with robotic scissors (which helps identify the pancreatic duct for later construction of the pancreaticojejunal anastomosis). The use of ther-

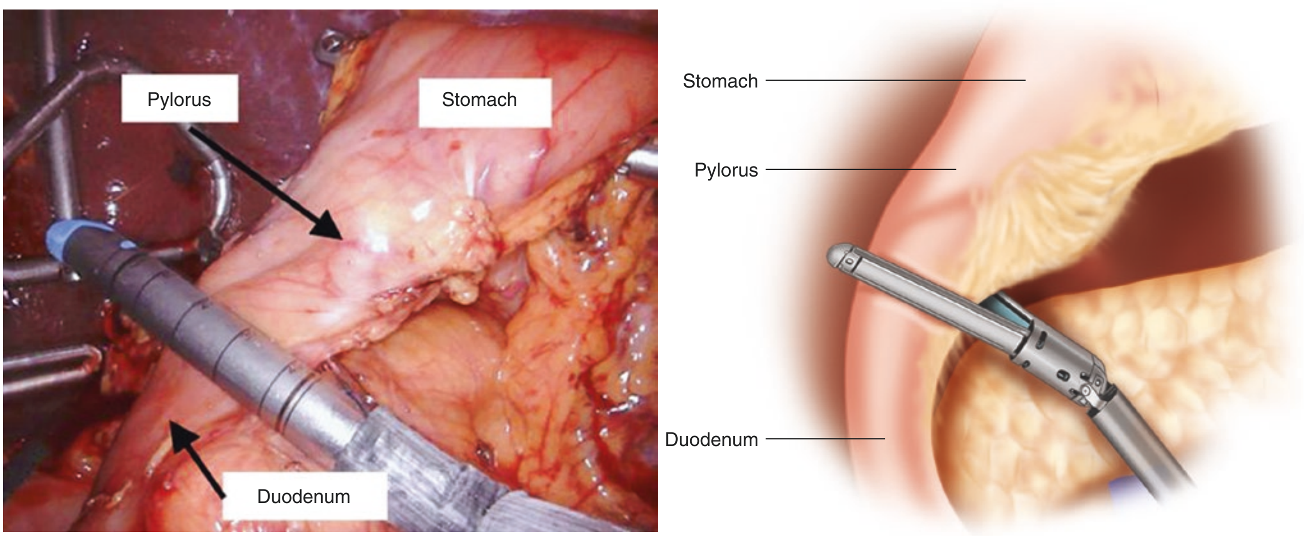


Fig. 28.8 Transection of duodenum

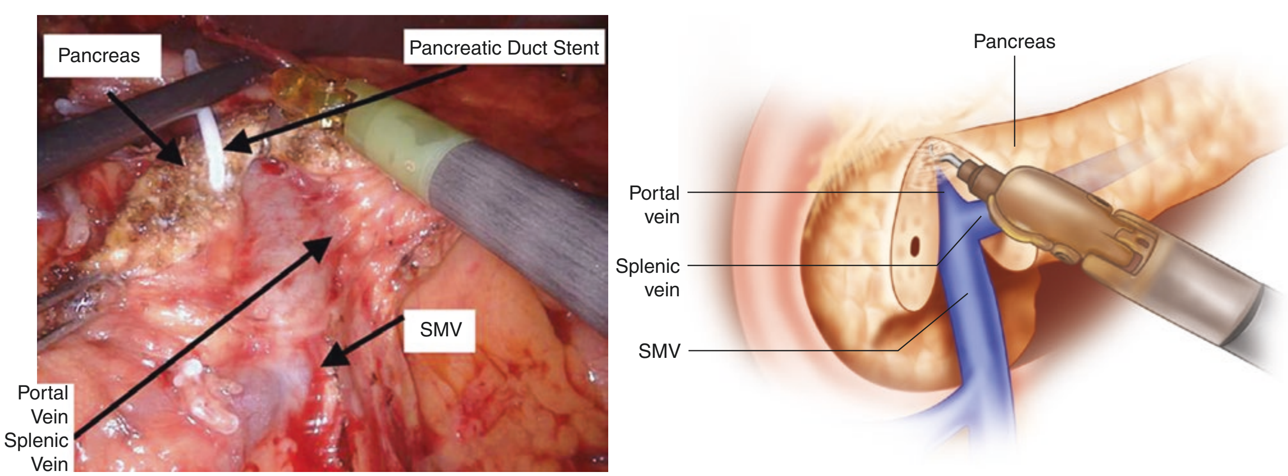


Fig. 28.9 Pancreatic transection and identification of the pancreatic duct

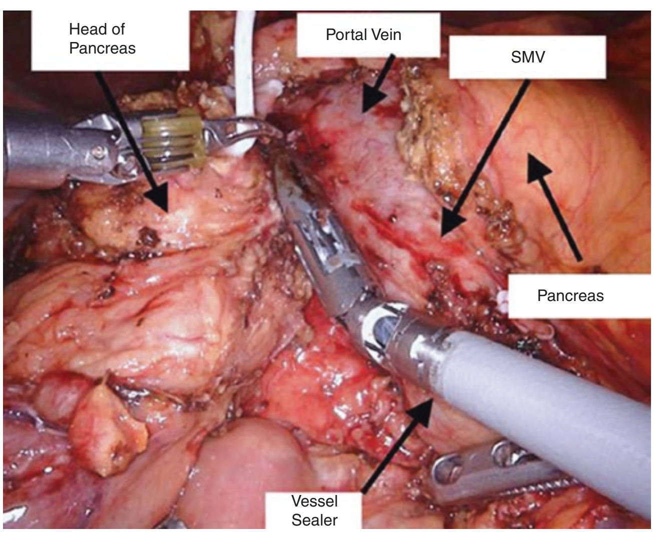
mal energy in dividing the pancreatic duct can seal the duct closed. The right lateral portion of the superior mesenteric vein/portal vein is bluntly teased away from the pancreatic head. The position of the superior mesenteric artery is identified by knowing its position to the left of the superior mesenteric vein. After the Kocher maneuver (described in the next section), the uncinate process and duodenal mesentery are separated from the portal vein/superior mesenteric vein. The vessel sealer instrument of the robot is helpful in this portion of the operation and is our preferred choice. It is uncommon to have to use clips for vascular control. Division of the uncinate process/duodenal mesentery begins caudal and proceeds cephalad until the pancreas and duodenum are freed (i.e., until the common hepatic artery is reached). The dissection continues along the lateral and posterior aspect of the portal vein to the common hepatic duct, which is finally transected.

Step 7. Pancreaticoduodenectomy Specimen Removal

Robotic arm # 1—Fenestrated bipolar device (alternating with a vessel sealer).
Robotic arm # 2—Camera.
Robotic arm # 3—Vessel sealer (alternating with hook cautery).
Robotic arm # 4—Atraumatic bowel grasper.

Once the head of the pancreas is separated from the body and tail, the mesentery of the third and fourth portions of the duodenum is divided, and the uncinate process is freed using the robotic vessel sealer along the superior mesenteric vein. The bedside surgeon may provide a dynamic gentle lateral retraction of the specimen to the patient's right using a laparoscopic atraumatic bowel grasper, though this is generally unnecessary. The laparoscopic suctioning device, through the Advanced Access Gelport®, may facilitate this dissection as well by providing some tissue retraction as needed. The lymphatic basin is included with the specimen.

The superior mesenteric artery must be carefully identified and protected from any injury as the dissection is carried along it. The specimen is also freed from the portal vein and superior mesenteric vein (Fig. 28.10). Once the specimen dissection of the superior mesenteric vein, superior mesenteric artery, and the portal vein attachments is complete, the distal common bile duct is encountered as it enters the head of the pancreas. The hepatic duct is divided with



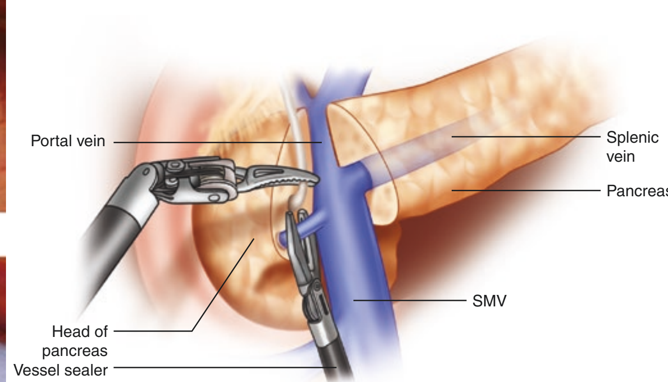


Fig. 28.10 Specimen extraction

either robotic hook cautery or scissors (Fig. 28.11). The bile duct lumen is identified and the bile effluent is suctioned off. If present, a bile duct stent is removed with the specimen. A cholecystectomy is undertaken next; this is often an opportunity for a younger, more inexperienced surgeon to participate and gain robotic experience. The gallbladder and the pancreaticoduodenectomy specimen are then placed into a laparoscopic EndoCatch Bag (Applied Medical, Rancho Santa Margarita, CA) and removed via the Advanced Access Gelport®. Water-soluble gel applied in the gel port and on the extraction bag helps "slip" the specimen out through the gel port. With lubrication, it is possible to deliver a specimen the size of a "lemon" through an incision the size of a "lemon drop."

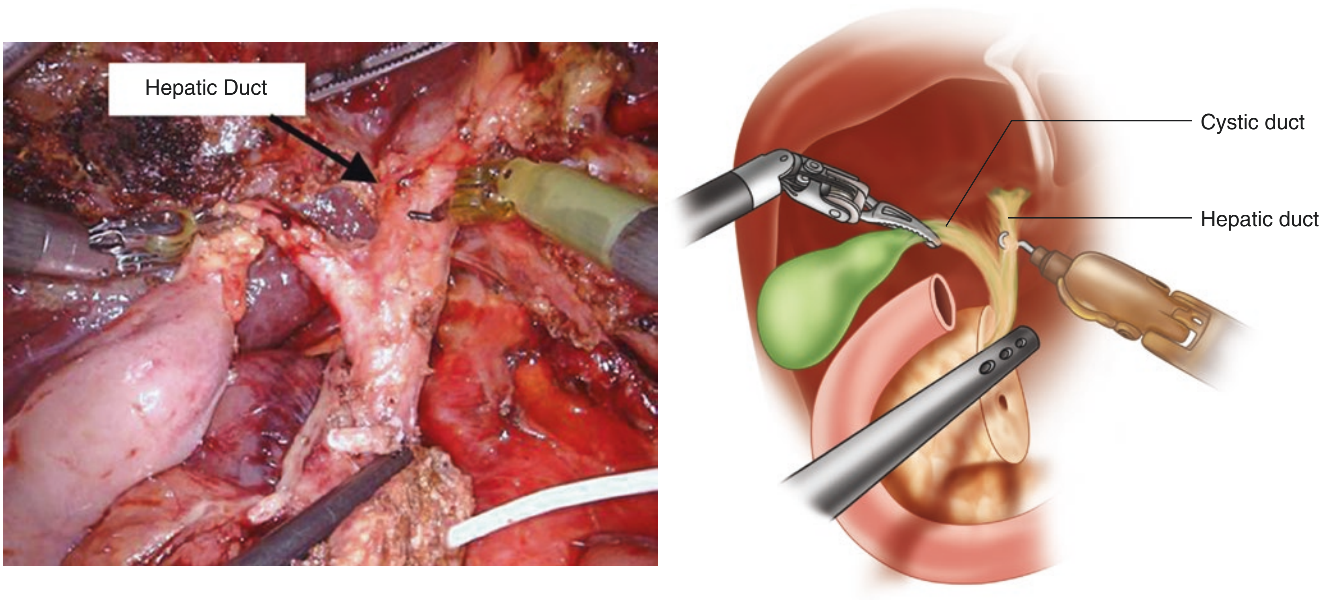


Fig. 28.11 Hepatic duct transection

Reconstruction

All sutures utilized in the reconstruction (i.e., hepaticojejunostomy, pancreaticojejunostomy, and duodenojejunostomy) are introduced into the peritoneal cavity through the Advanced Access Gelport®.

Step 8. Construction of the Hepaticojejunostomy

Robotic arm # 1—Needle driver.
Robotic arm # 2—Camera.
Robotic arm # 3—Needle driver.
Robotic arm # 4—Atraumatic bowel grasper.

A suitable length of proximal jejunum is brought under the root of the mesentery and advanced cephalad toward the porta hepatis and the cut edge of the pancreas. The laparoscopic liver retractor should be positioned in such a way to easily visualize the hepatic duct lumen. The proximal jejunal limb is held in position using an atraumatic bowel grasper in the robotic arm # 4; it holds the bowel in position by grasping it proximal to the anastomosis. Doing the hepaticojejunostomy before the pancreaticojejunostomy is our strong preference.

The cut end of the bile duct is further opened along the ventral surface of the bile duct if the duct is small (less than 1 cm) to increase the cross-sectional area of the bile duct anastomosis to help prevent a clinically apparent stricture. Construction of a single-layer anastomosis is started at the 9-o'clock position using a 3–0 V-Loc™ (Medtronic, Minneapolis, MN) suture in a running fashion (Fig. 28.12). The stitch is run dorsally toward the 3-o'clock position and kept tight after each needle passes. Another V-Loc™ suture (starting at the 9-o'clock position) is used to construct the ventral aspect of the anastomosis. Both stitches are tied, on the outside of the duct lumen, at the 3-o'clock position, after ensuring that the suture is snug. The anastomosis is inspected and additional sutures are placed as needed.

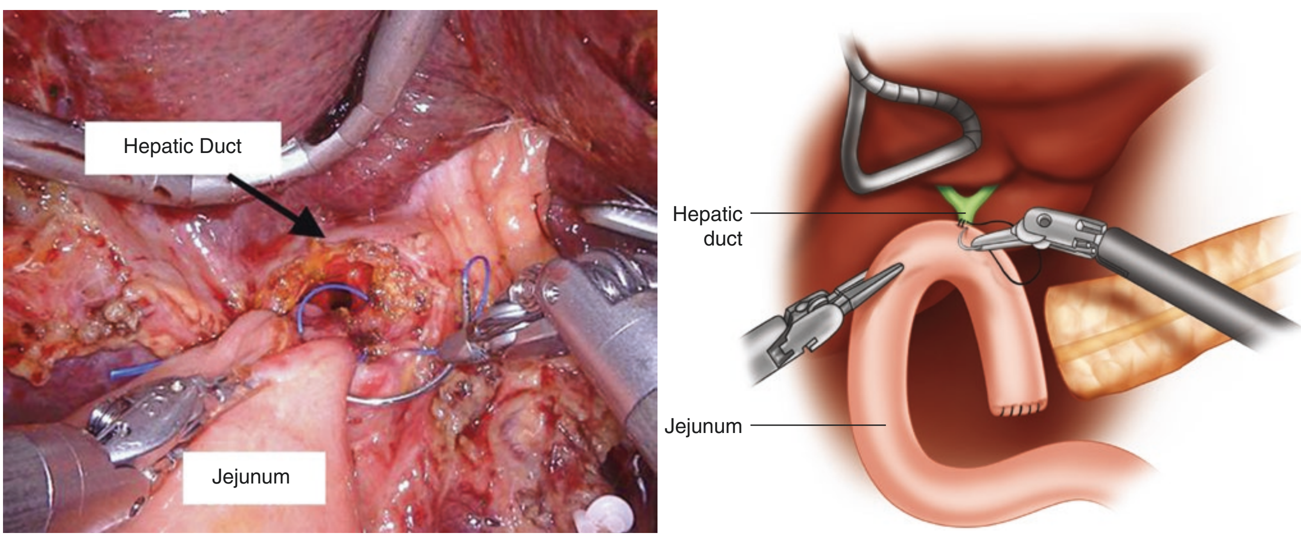


Fig. 28.12 Hepaticojejunostomy

Step 9. Construction of the Pancreaticojejunostomy

Robotic arm # 1—Needle driver.
Robotic arm # 2—Camera.
Robotic arm # 3—Needle driver.
Robotic arm # 4—Atraumatic bowel grasper.

The pancreaticojejunostomy is constructed using a two-layer anastomosis with 3–0 V-Loc™ sutures (Fig. 28.13). The posterior layer is undertaken by bringing the pancreatic parenchyma to the seromuscular layer of the jejunum in a running fashion. The pancreatic duct is then identified. The duct is generally quite posterior, so don't include it in the posterior layer of the anastomosis. The duct-to-jejunum anastomosis is undertaken after making a *small* enterotomy by placing interrupted sutures (at the 6-,9-, 3-, and 12-o'clock positions) using 4–0 or 5–0 polypropylene sutures. All the knots are tied on the outside of the pancreatic duct anastomosis (i.e., outside the lumen). The anterior layer of the pancreaticojejunostomy anastomosis is constructed by bringing the anterior capsule of the pancreas to the seromuscular layer of the jejunum in a running fashion. The posterior and anterior layer stitches are then tied together, which completes the pancreaticojejunal anastomosis.

Step 10. Reconstruction of the Ligament of Treitz

Robotic arm # 1—Needle driver (alternating with an atraumatic bowel grasper).
Robotic arm # 2—Camera.
Robotic arm # 3—Needle driver.
Robotic arm # 4—Atraumatic bowel grasper.

The transverse colon is elevated ventral and cephalad with atraumatic bowel graspers which exposes the prior location of the ligament of Treitz, i.e., the defect under the mesenteric vessels. The jejunal limb coming from the bile duct is identified and secured to the root of the transverse colon mesentery with a 3–0 V-Loc™ suture. The goal of reconstructing the ligament of Treitz is to avoid potential small bowel herniation under the root of mesentery alongside the jejunal limb. Careful attention must be paid not to include any mesenteric vessel branches during placement of the stitches. It is also important to avoid excessive distal traction on the jejunal limb, which in turn can promote mechanical tension on the hepaticojejunostomy and pancreaticojejunostomy.

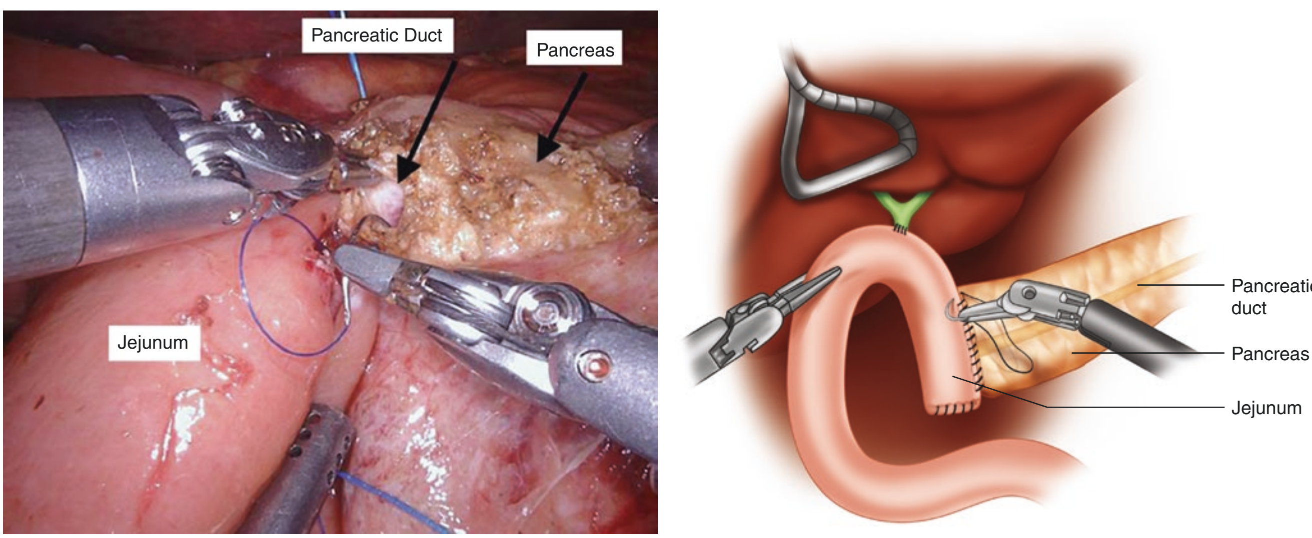


Fig. 28.13 Pancreaticojejunostomy

Step 11. Construction of the Duodenojejunostomy

Robotic arm # 1—Needle driver.
Robotic arm # 2—Camera.
Robotic arm # 3—Needle driver.
Robotic arm # 4—Atraumatic bowel grasper.

The surgical bed is leveled (from reverse Trendelenburg position). The duodenojejunostomy is constructed using a single-layer running anastomosis with 2 3–0 V-Loc™ sutures in a similar fashion to the hepaticojejunostomy (Fig. 28.14). Construction is started at the 9-o'clock position (looking at the cut end of the duodenum) using a 3–0 V-Loc™ suture in a running fashion. The stitch is ran dorsally to the 3-o'clock position and kept tight after each needle pass. Utilizing a Gambee technique may aid in making a nice, clean anastomosis. Another V-Loc™ suture, which also begins at the 9-o'clock position, is used to construct the ventral aspect of the anastomosis. Both stitches are tied at the 3-o'clock position after ensuring that the sutures are tight. The afferent and efferent limbs are anchored to the distal stomach to avoid tension or twisting of the duodenojejunostomy.

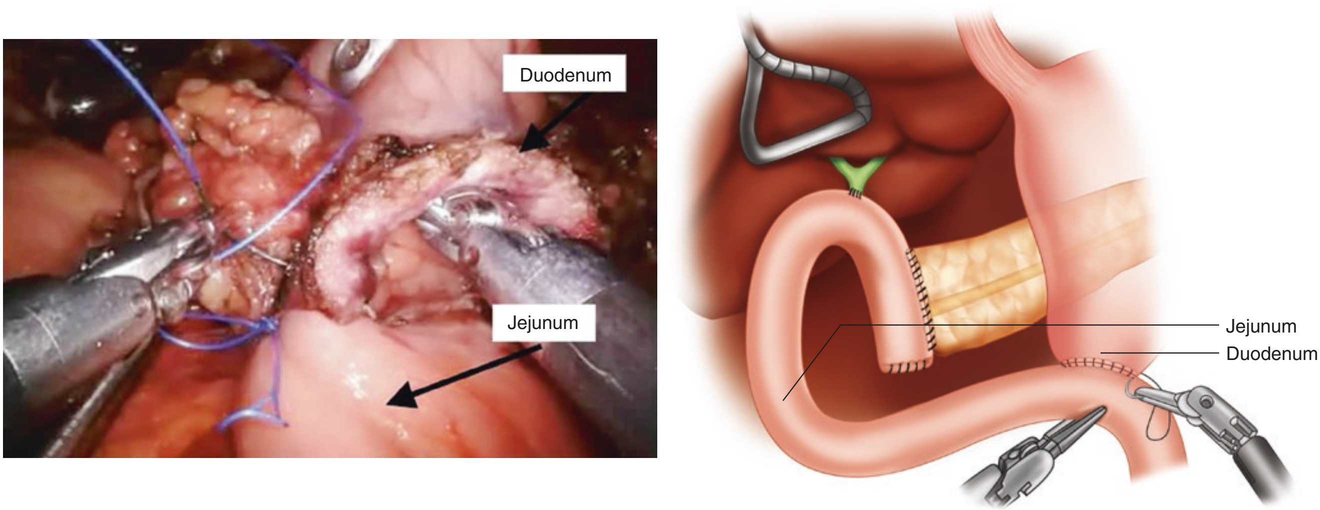


Fig. 28.14 Duodenojejunostomy

Step 12. Placement of Drain and Closure

A closed suction 10F Jackson-Pratt drain is routinely placed about the hepaticojejunostomy and pancreaticojejunostomy. The Jackson-Pratt drain is brought out through the right upper quadrant 5 mm AirSeal® Access Port incision (Fig. 28.15). The drain is sutured to the skin with a nylon suture.

To help decrease postoperative pain, the diaphragm is irrigated bilaterally and liberally with a solution of 7.5 mL of 0.25% Marcaine™ in 250 mL of normal saline. All incisions are closed along anatomic layers. Absorbable monofilament sutures are used for fascial closure, and the skin is approximated with interrupted 3–0 absorbable sutures and Steri-Strips. To further aid in postoperative pain control, we routinely inject all incisions with a solution of 20 mL of Exparel® (Pacira Pharmaceuticals, Parsippany, NJ) in 30 mL of normal saline. A sterile 1.5 × 6 silver dressing (Therabond® 3D, Alliqua Biomedical, Langhorne, PA) is applied to all incisions followed by sterile 2 × 2 gauze; it is covered with a Tegaderm™ (Tegaderm transparent dressing, 3M™, St Paul, MN) dressing. This watertight dressing allows patients to shower at home. The dressing is removed at 5–7 days postoperatively.

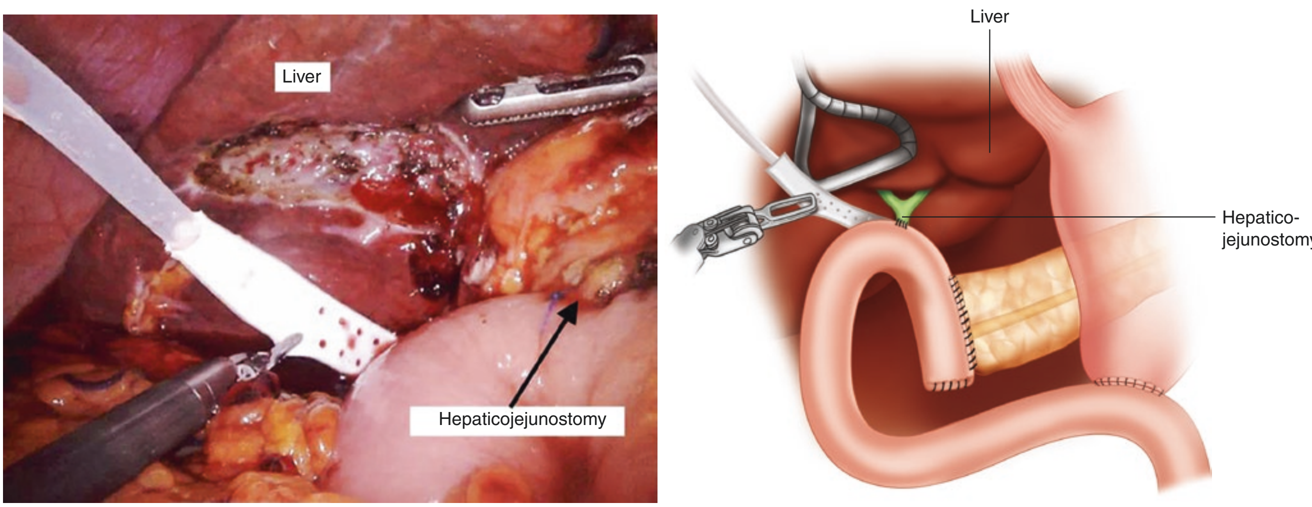


Fig. 28.15 Placement of drain

Intraoperative Care

Judicious intraoperative fluid administration is emphasized. We follow perioperative goal-directed fluid therapy (PGDFT) principles, guided by the ClearSight™ EV1000 System (Edwards Lifesciences, Irvine, CA). Utilizing this system, hemodynamic metrics (i.e., cardiac output, stroke volume, stroke volume variation, etc.) are continuously monitored within a strict protocol to allow for precise volume administration. Percentage of stroke volume variations is followed to estimate fluid status and used to determine whether intravenous albumin/fluid bolus is needed. All the steps and points are strictly adhered to by the anesthesia team in our enhanced recovery after surgery (ERAS) protocol.

Postoperative Care

- POD 1: CBC and CMP daily.
- POD 2: Foley out, NGT out, start clear liquid diet.
- POD 3: Intraperitoneal drain amylase levels, if it's within normal value, drain is removed.
- Physical therapy: twice a day.
- Pain control: intravenous Tylenol (1000 mg every 6 h for 3 days) in addition to intravenous ketorolac (15 mg every 6 h for 3 days), oral gabapentin, and oral celecoxib. Breakthrough pain is managed with intravenous 0.5–1 mg hydromorphone (when patients are still unable to tolerate a diet).
- Patients are encouraged to chew gum during recovery to help stimulate gut function/motility.

Postoperative Complications

- Atelectasis
- Pneumonia
- Urinary tract infection
- Wound infection
- Pancreatic anastomosis leak
- Intra-abdominal abscess
- Hepaticojejunostomy stricture

Tricks of the Master

- With the intuitive da Vinci Xi® system, the operating room bed is paired with the robotic system, which enables easy positional changes throughout the operation without constant undocking and redocking of the robotic system (effective way to use gravity to provide adequate exposure).
- The role of an experienced bedside surgeon cannot be over emphasized. The bedside surgeon is crucial in providing appropriate traction and organ manipulation to maintain optimal exposure and keeping the operative field bloodless.
- Early/swift conversion to open pancreaticoduodenectomy if failure to progress (for more than 20 min due to difficult dissections), significant intraoperative bleeding, and intolerance to carbon dioxide pneumoperitoneum.
- The current da Vinci Xi® system utilizes an 8-mm laparoscope (instead of a 15 mm) as the robotic camera, which allows the utilization of the camera in any trocar.
- We prefer to use V-Loc™ barbed sutures for the robotic anastomoses since they provide and maintain tension across the tissue interface after each needle passes. We found this to be very useful since loosening of the running anastomotic stitches is unlikely. In both open and robotic operations, corners are points where anastomotic leaks are commonly seen. Therefore, we routinely reinforce both corners with additional full-thickness stitches. Careful attention must be given after completion of any anastomosis to ensure the absence of any mechanical twisting or tension.
- We routinely place a closed suction drain about the hepaticojejunostomy and pancreaticojejunostomy. Drain amylase level is checked on postoperative day 3, 24 h after the patient was started on a clear liquid diet. The drain is removed at the bedside when drain amylase levels are within normal levels.
- On postoperative day 2, nasogastric tubes are removed. We begin our patients on Ensure Clear and then advance to clear liquid diet.
- On postoperative day 3, patients are advanced to full liquid diet. Patients are discharged home.
- Postoperative clinic visit in our office occurs in 7–10 days following discharge.

One of the major concerns about robotic surgery is the cost of purchasing and maintaining a robotic surgical system. Data about costs are lacking and have been explored for single procedures such as distal pancreatectomy [23]. Short hospital stays deriving from minimally invasive procedures do translate into cost cuts for health-care institutions; whether the robotic platform is overall cost-effective is difficult to evaluate. However, we have reported that costs can become affordable and cost-effective if used to the maximum potential (i.e., in high-volume centers) [9]. The robotic platform will eventually become more affordable over time, and institutions with the latest technologies may hold a competitive edge over other institutions with regard to patients seeking treatment. Pancreatic surgery remains one of the most successful fields of application of the robotic platform, and its use is growing at a remarkable pace.

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