Chapter 16
Robotic Pancreaticoduodenectomy

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16.1 Introduction

Pancreaticoduodenectomy (PD) is the standard surgical procedure for pancreatic head cancer and other peri-ampullary neoplasms [1]. Named after Allen Oldfather Whipple who first performed the operation as a one stage procedure, in 1935 [2], it was initially described by Alessendro Codivilla in Italy in 1898 and Walther Kausch in Germany in 1912. Over the course of the last three decades, improvements in surgical technique and perioperative care have led to markedly low mortality rates of under 2% at high-volume pancreatobiliary centers [3]. Despite this improvement in mortality rates, morbidity rates following open pancreaticoduodenectomy remained high, approaching 50% in some series [4].

The robotic platform offers a minimally-invasive alternative to open PD. When performed by experienced surgeons at high-volume centers on select patients, comparative studies demonstrate a decreased conversion rate for robotic PD (RPD) compared to its laparoscopic counterpart, and reductions in morbidity with non-inferior oncologic outcomes when compared to the open approach [5–10]. At the University of Pittsburgh, we implemented a robotic pancreas program in 2008 and have performed over 700 RPDs to date. Our initial studies focused on identifying the learning curve (nearly 80 cases for new adopters), with subsequent studies demonstrating superior outcomes to the open approach in highly selected patient cohorts. Over the last 5 years, we focused on safely disseminating our RPD technique to new adopters.

In this chapter, we describe a comprehensive step-by-step approach for robotic pancreaticoduodenectomy as it is performed at the University of Pittsburgh. We

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describe pitfalls and obstacles that may be faced by the operating surgeon along every step and offer practical solutions to avoid and handle the technical challenges associated with this complex operation.

16.2 Clinical Presentation

Pancreatic ductal adenocarcinomas (PDAC), and its variants, account for 90% of all pancreatic malignancies and tend to develop at a median age of 70 years with a slight predilection towards male gender [11, 12]. Only 15–20% of PDAC patients are amenable to curative-intent surgical resection as the majority (80–85%) have unresectable or metastatic disease at the time of diagnosis [13, 14]. The development of symptoms typically coincides with advanced stage disease at the time of presentation [14]. Common symptoms include abdominal or mid-back pain, anorexia, fatigue, weight loss, floating stools, dyspepsia, and obstructive jaundice. Furthermore, new onset diabetes mellitus in patients 50 years or older may be a warning sign for an underling pancreatic malignancy. Occasionally, the tumor can obstruct the pancreatic duct or duodenum and lead to pancreatitis or gastric-outlet obstruction respectively.

16.3 Preoperative Evaluation

A comprehensive clinical assessment is crucial in the evaluation of pancreatic cancer patients. A thorough assessment for commonly cited risk factors such as smoking, obesity, family history of malignancy, chronic pancreatitis, and alcohol consumption should be sought. Physical examination may reveal scleral icterus, malignant ascites or significant wasting and cachexia. Laboratory evaluation should include liver function tests, a complete metabolic profile and carbohydrate antigen level 19-9 (CA19-9) levels. Although non-specific at diagnosis, not secreted in upto 20% of PDACs and often falsely elevated in the presence of jaundice, CA19-9 is a useful biomarker in detecting recurrence and assessment of tumor response to systemic therapy [15, 16].

Cross-sectional imaging is critical in the initial evaluation, staging and preoperative planning for pancreatic head cancers. The anatomic location of the tumor with respect to the surrounding visceral structures and abdominal vessels dictates resectability status (resectable, borderline-resectable, locally-advanced disease/unresectable, metastatic) which in turn, dictates treatment algorithms [16]. The National Comprehensive Cancer Network (NCCN) recommends staging with a triphasic-pancreatic protocol-CT scan of the abdomen as the gold standard imaging modality to evaluate and stage pancreatic malignancies. The panel also recommends CT scan of the chest and pelvis for the detection of metastatic disease, magnetic resonance imaging for indeterminate liver lesions, and PET/CT in high-risk patients to detect

extrapancreatic disease. Endoscopic ultrasound (EUS) is the preferred modality for obtaining a biopsy, while endoscopic retrograde cholangiopancreatography (ERCP) or percutaneous transhepatic cholangiography (PTC) can be utilized to place a stent for biliary decompression (if neoadjuvant therapy is needed) or as palliation for biliary obstruction secondary to unresectable disease [16, 17].

16.4   Technique

16.4.1   Patient Positioning

After induction of general endotracheal anesthesia, a nasogastric (NG) tube and a Foley catheter are inserted. Arterial line placement for intraoperative blood pressure monitoring is usually placed, however placement of a central venous line is at the discretion of the surgeon and the anesthesiologist. The patient is positioned on the split leg table, with both legs abducted to the "B" position. The right arm is tucked, and the left arm is extended to 60°. Appropriate padding of all pressure points is ensured to prevent neurovascular injury during the procedure. The patient should be anchored well to the table with circumferential straps placed over the chest and legs, as most of the operation is done in steep Trendelenburg position. Depending on the robotic platform available, the table is rotated 45° away from the anesthesia to dock the da Vinci SI robot (Intuitive Surgical, Sunnyvale, CA) over the head of the patient, or remains in its natural position for XI platform which is docked from the side (Fig. 16.1).

16.4.2   Trocar Placement and Explorative Laparoscopy

In total, 7 ports are placed for RPD (Fig. 16.2). Access to the abdomen is achieved under direct visualization using an optical separator trocar and a 5 mm 0° laparoscope in the left midclavicular line, 3–4 cm above the level of the umbilicus. Insufflation pressure should be set to 15 mmHg. A diagnostic laparoscopy to asses for gross peritoneal and/or liver disease is performed. If none is found, the remainder of the ports are placed in the following configuration under direct visualization: A 12 mm (for Si or 8 mm for XI) camera port is placed 3–4 cm above and to the right of the umbilicus in the same transverse line as the optical separator trocar. Next, three robotic 8 mm trocars are placed along the same transverse line: The original optical trocar is replaced with the first robotic trocar (R1), while the second (R2) and third (R3) robotic trocars are placed on the right side of the abdomen, at the mid-clavicular and anterior axillary lines, respectively.

Two bedside assistant trocars are then placed in the following configuration; a 5 mm trocar is placed in the right mid-clavicular line bisecting the camera trocar and
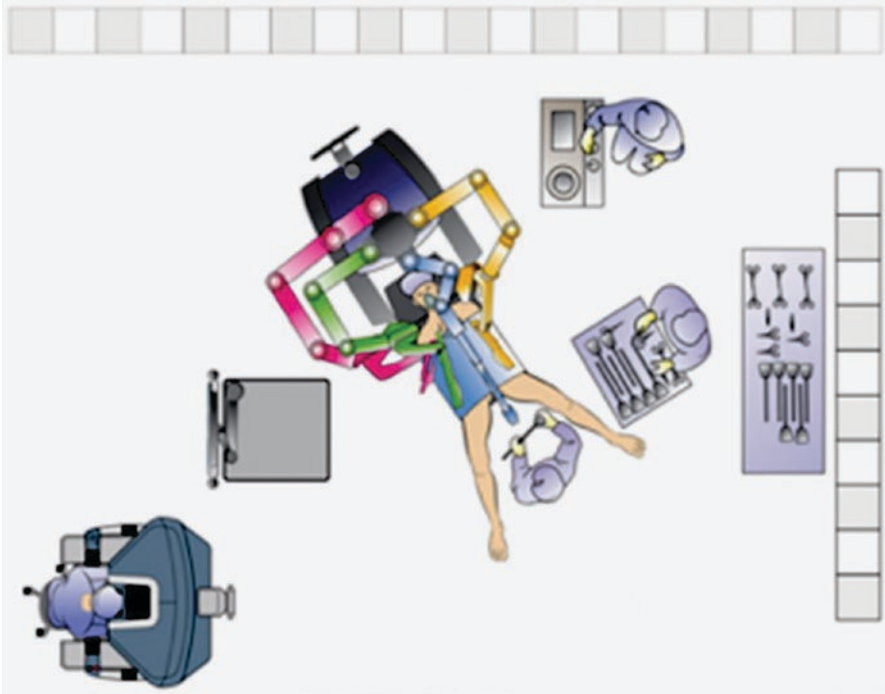
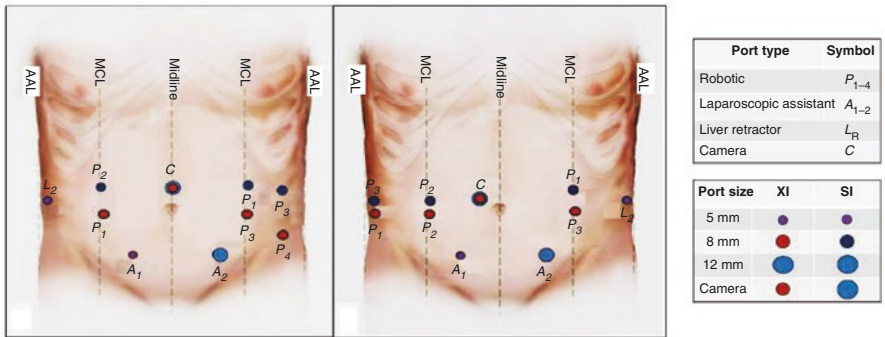**Fig. 16.1** Patient positioning for the SI robot © 2014 Intuitive Surgical, Inc.

Fig. 16.2 Port placement A. XI B. SI

the R2 robotic trocar. The second assistant port is a 12-mm trocar placed in the left lower quadrant at the left mid-clavicular line bisecting the camera trocar and the robotic R1 trocar. Finally, a 5 mm trocar is placed along the left anterior axillary line to install the liver retractor. A Mediflex liver retractor (Mediflex ®Surgical Products, Islandia, NY) is then applied to provide cephalad retraction of the liver. Importantly, at least one-hand breadth between robotic trocars should be maintained to optimize

the ergonomics of the robot (Fig. 16.2). Once all the trocars are correctly placed, the robot is docked over the patient's head (SI) or right side (XI) with two robotic arms on the right side (a cadiere in R3-lateral arm, fenestrated biopolar in R2—medial arm), one at the left side (hook unipolar in R1), and the robotic camera in the middle trocar.

Troubleshooting *In patients who have higher body mass index (BMI > 35), particularly those with central obesity, all trocars should be shifted superiorly. For patients with lower BMI (<25), all trocars should be shifted inferiorly. Care should be taken to avoid injury to the inferior/superior epigastric vessels, which could be in the direct line of trocar placement. The XI trocars should be placed slightly higher the SI robot. The robotic trocars should be placed at a 90-degree angle of entry with the skin, while the bedside assistant trocars should be placed at a 45 degree angle pointing cephalad to the resection field.*

16.4.3 Resection Phase

16.4.3.1 Mobilization of Right Colon, Kocherization of the Duodenum and Division of the Ligament of Treitz

Access to the lesser sac is first attained through the avascular plane of the gastrocolic ligament using a combination of monopolar cautery and the 10 mm LigaSure™ (Covidien, Mansfield, MA). During this step, the stomach is sequentially retracted cephalad and anteriorly using robotic arm R3. Dissection is carried all the way distally, carefully separating the transverse mesocolon from the gastroepiploic vein pedicle, until the hepatic flexure is completely mobilized. This step is crucial to allow full access to the duodenum and the head of the pancreas.

This is followed by Kocherization of the duodenum using a combination of blunt dissection and monopolar cautery. During this step, continuous sequential traction is applied on the duodenum, anteriorly and cephalad, by robotic arm R2. Furthermore, the bedside assistant maintains continuous counter-traction by pulling the transverse colon and hepatic flexure towards the left lower quadrant. After the conclusion of this step, the inferior vena cava, left renal vein and the ligament of Treitz should be clearly delineated.

The ligament of Treitz is then divided from the right-side using hook monopolar electrocautery. This step allows complete mobilization of the duodenum and creation of a tunnel for the proximal jejunum to eviscerate into the right upper quadrant (RUQ). 10 cm distal to the divided ligament of Treitz, a rent in the jejunal mesentery is created, and the jejunum is divided using an Endo-GIA (Covidien, Mansfield, MA) 60 mm stapler placed through the 12 mm assistant trocar. Finally, the mesentery of the proximal jejunum and the fourth and third portion of the duodenum is divided progressively using the energy sealing device up to the inferior border of the uncinate process. This step is crucial to create the plane needed for dissection of the
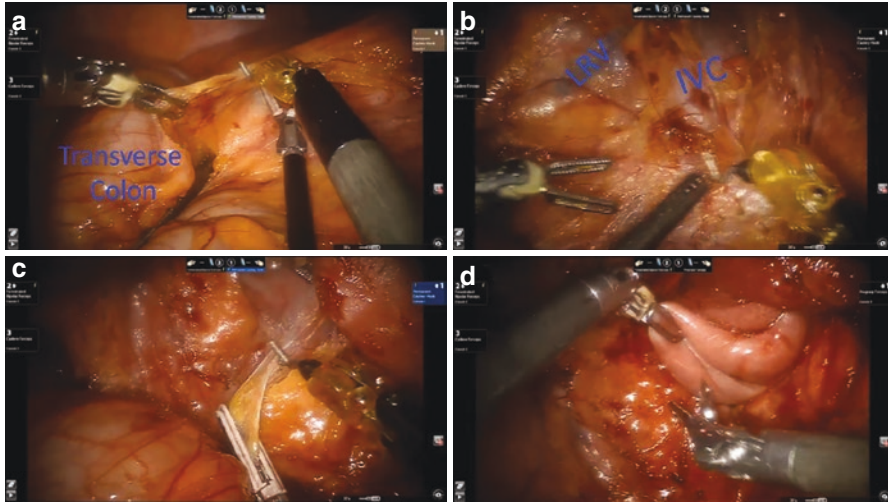
Fig. 16.3 Mobilization of the hepatic flexure by dividing the gastrocolic ligament and the white lines of Toldt (**a**). This allows complete Kocherization of the duodenum whilst it's being retracted "up & out" (**b**). Exposure of the left renal vein (LRV), inferior vena cava (IVC) and the suspensory ligament of the duodenum. The ligament of Treitz is divided from the right side (**c**), until a tunnel is created for the jejunum to be brought up toward the RUQ (**d**)

superior mesenteric vein (SMV) and Portal Vein (PV) junction that ensues later during the operation (Fig. 16.3).

Troubleshooting *This step requires considerable coordination between the console and bedside surgeons. In particular, the bedside assistant needs to be dynamic in retracting the hepatic flexure caudad to expose the third and fourth potion of the duodenum and dissect the ligament of Treitz. For this, a near total Catell-Braasch mobilization is performed to the point where the hepatic flexure can be retracted towards the left lower quadrant. Failure to rotate the hepatic flexure towards the left lower quadrant can lead to avulsion of the middle colic or gastrocolic veins causing significant hemorrhage. Performing this step can be challenging in obese patients and males in particular due to the larger mesocolon.*

### 16.4.3.2   Division of the Stomach and Dissection of the Porta Hepatis

The Pars flaccida is opened widely and dissection along the lesser curvature of the stomach is carried inferiorly, dividing the right gastric and right gastroepiploic close to the lesser and greater curvatures of the stomach respectively using a combination of bipolar electrocautery and LigaSure. The stomach is then divided just proximal to the pylorus using 2 loads of endo GIA 60 purple cartridge. Next, the distal transected portion of the stomach is grasped with a Cadiere in R3 and retracted laterally towards the RUQ. This traction facilitates optimal exposure for portal dissection.

Proceeding from right to left, the lymph nodes anterior to the common hepatic artery (CHA) (station 8A) are dissected using monopolar cautery and their feeding vessels, which usually emanate from the celiac trunk, are controlled with LigaSure by the bedside assistant. These lymph nodes are then sent to permanent pathology. The dissection is carried laterally until the right gastric artery is identified, which is doubly clipped with a 5-mm Endo clip (Covidien) by the bedside assistant and divided. This step allows clear delineation of the common and proper hepatic arteries (CHA and PHA) proximal and distal to the origin of the gastroduodenal artery (GDA) respectively. Next, regional lymphadenectomy along the portal vein (stations 8p & 12p) is completed while gentle traction is being applied to the CHA anteriorly using a closed bipolar grasper. The suprapancreatic portal vein is exposed. Once this step is complete, attention is turned to the GDA which is dissected circumferentially with a robotic hook (R1) and vessel looped. Arterial anatomy should be clearly delineated before dividing the GDA-either by preoperative high-quality CT (triphasic) imaging or intraoperative robotic ultrasound with Doppler color flow. In addition, pulsation in the RHA and LHA should be visualized after the GDA is 'test clamped'. If the above is achieved, the GDA can be safely divided using a 45-mm vascular load angled tip. A 10-mm robotic Hem-o-lok (Weck Closure Systems, Research Triangle Park, North Carolina) clip is placed on the GDA stump to mark its location.

Next, the CBD is dissected circumferentially using the hook monopolar cautery (R1) and the bipolar grasper (R2). The CBD is gently pulled to the right using the bipolar in R2, and the intervening lymphatic tissue (station 12b) is dissected and sent to pathology. The CBD is then transected using an Endo GIA 45-mm gold load with angled tip, to minimize biliary spillage during the rest of the procedure. After clear delineation of the portal triad, dissection is carried inferiorly along the anterior border of the PV until the pancreatic neck is reached, sweeping any remaining lymphoid tissue towards the specimen. This provides a "landing zone" for the pancreatic transection that follows creation of the retropancreatic neck tunnel (Fig. 16.4).

Troubleshooting When opening the gastro-hepatic ligament, an accessory/ replaced left hepatic artery from the left gastric artery should be protected. During portal dissection, a strict "no-touch" technique is advised when dissecting vascular structures. If during this process, the anterior wall of the PV is injured, repair is accomplished with 4-0 prolene stitches taken transversely, in an interrupted fashion. A precautionary minilap pad placed in the LUQ ready for use to tamponade bleeding and apply pressure is recommended. Care should be taken while dissecting the CBD, since small tributaries from the PV can be seldom encountered during this step and need to be controlled with LigaSure to prevent troublesome bleeding. Finally, preoperative triphasic CT scan is essential in delineating a replaced right hepatic artery (from the SMA); this vessel -if present- can be injured during division of the CBD if not recognized. Finally, the gallbladder should not resected at this stage, since it provides a 'handle' for the liver retractor; It can be resected when the PD dissection is done.
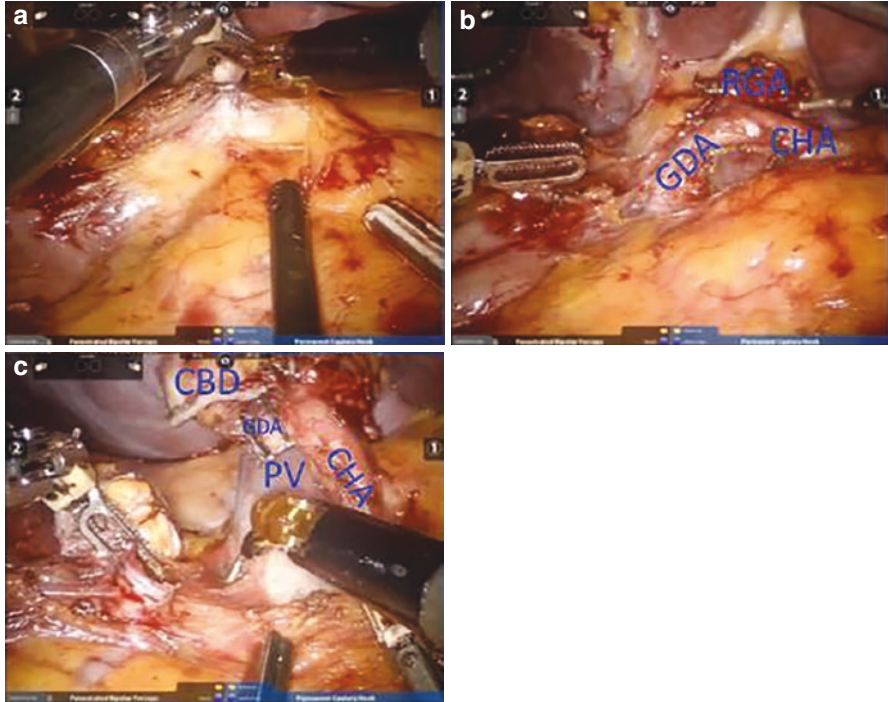
Fig. 16.4 Portal dissection: with the R3 arm retracting the transected stomach laterally towards the RUQ, dissection of the 8A lymph node proceeds from right to left (**a**). After the lymph node is removed, and the right gastric artery (RGA) is clipped and divided, the gastroduodenal artery (GDA) is skeletonized by clearing the adjoining lymphatic tissue. The common hepatic artery (CHA) both proximal and distal to the origin of the GDA is clearly delineated (**b**). Portal lymph-adenectomy is complete, the CBD is transected and dissection process caudally anterior to the portal vein (PV) until the "landing zone" is created (**c**)

16.4.3.3 SMV/PV Dissection and Transection of the Pancreatic Neck

This step begins at the inferior border of the pancreas. Using a cadiere or prograsp in R3 a continuous "up and out" traction force is applied to the duodenum/staple line. This allows clear demarcation of the SMV at the infra-pancreatic border and the entry point of the gastro-epiploic vein pedicle to the SMV. While the inferior pancreatic edge is being retracted anteriorly and superiorly using R2 (closed fenestrated Bipolar forceps), the bedside assistant retracts the mesolon inferiorly. This provides counter tension so dissection can be safely performed along the inferior border of the pancreas to identify the SMV using the hook monopolar in R1. Once located, dissection proceeds along the anterior surface of SMV in a cephalad direction, using hook monopolar cautery (R1) to divide small filamentous attachments along the pancreatic neck tunnel. This dissection is continued until the previously described supra-pancreatic dissection plane is reached. During this critical phase of
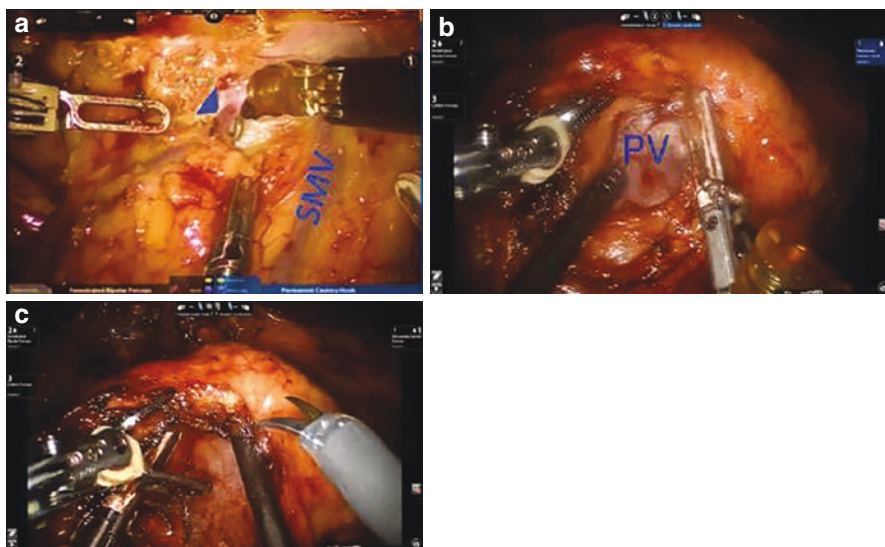
Fig. 16.5 Retro/infra-pancreatic dissection: with continuous "up & out" traction applied to the specimen with R3, the superior mesenteric vein (SMV) is identified at the inferior margin of the uncinate process. The dissection proceeds inferiorly until the trunk of Henle (blue arrowhead) is identified and controlled with LigaSure (**a**). Next, the retropancreatic tunnel is developed. With upward traction being applied to the pancreas with the bipolar forceps in R2, monopolar cautery in R1 is used to divide the flimsy attachments to the vein while a blunt instrument is used to protect the underlying PV/SMV by applying gentle downward traction (**b**). After the superior "landing zone" is reached, the pancreas is divided sharply with "hot" robotic shears (**c**)

the operation, the right gastroepiploic vein is identified and divided with sequential LigaSure burns. The middle colic vein can usually be preserved. It is crucial to identify the right venous branch of the middle colic vein (trunk of Henle); a common venous branch that joins the right gastroepiploic vein and the SMV. It should be controlled with multiple sequential burns using the LigaSure.

Finally, division of pancreatic neck is carried out using the hot monopolar shears in R1. To protect the SMV/PV during this step, the bedside assistant provides continuous gentle downward traction on the SMV in the retro-pancreatic tunnel using a blunt instrument (Suction/irrigation or grasper). This step is continued until the pancreatic duct is reached. It should be divided sharply without the use of heat to avoid thermal injury (Fig. 16.5).

Troubleshoot *The gastrocolic trunk can cause troublesome bleeding if not effectively controlled. The most effective modality is multiple consecutive burns using the LigaSure device right at its junction with the SMV; using metallic clips or ties are ineffective and can fall off during the course of the operation. Before pancreatic transection, care should be given to the superior and inferior transverse pancreatic arteries which are pre-coagulated with the fenestrated bipolar in R2 in lieu of the traditional figure of 8 transfection sutures used to control those vessels.*

#### 16.4.3.4 Pancreatic Head and Uncinate Dissection (Fig. 16.6)

Using the Cadiere in R3, the specimen is retracted toward the right lateral abdominal wall. With this maneuver, the uncinate process is 'opened up' allowing safe dissection and margin clearance. Using hook monopolar cautery in R1 and fenestrated bipolar forceps in R2, filamentous attachments from the SMV/PV to the uncinate process are divided. During this process, the bedside assistant again protects the SMV/PV by providing gentle downward/leftward traction using a blunt instrument. The superior pancreaticoduodenal vein (of Belcher) and small venous tributaries from the first jejunal branch are identified during this process and controlled with multiple burns of the LigaSure. The first jejunal vein should be preserved (when possible if not involved by tumor) and reflected toward the left side. Once this is accomplished, the dissection of the superior mesenteric artery (SMA) layer ensues.

Dissection of the periadventitial SMA layer is performed using the hook monopolar electrocautery in R1 and the LigaSure. Care should be taken to stay at the lateral/anterior border of the SMA (along the plane of Leriche) to optimize the retroperitoneal margin. Exposure is enhanced by dynamically retracting the specimen toward the right lateral abdominal wall using the Cadiere or Prograsp forceps in R3. The inferior pancreaticoduodenal artery can be identified, is dissected at its base from the SMA, and ligated with metallic clips or the LigaSure. (Fig. 16.6). The specimen is then released and hemostasis is ensured.

Troubleshooting   In a majority of cases, the first jejunal vein arises from the right side of the SMV at the level of the inferior uncinate border and courses to the left posterior to the SMA. It has several uncinate branches. These can be easily avulsed causing significant bleeding. Gentle disseaction is necessary to identify them with the robotic hook. They should be divided with the LigaSure. Occasionally, the first jejunal vein needs to be transected. This is best done with a vascular stapler 45 mm load. Significant bleeding during this step of the operation can be managed by tamponade using the previously placed minilap. This allows for the surgical team to exchange the bipolar and hook in R1 and R2 to needle drivers for suture placement, or prepare for conversion to laparotomy.

16.4.3.5 Cholecystectomy & Specimen Extraction

The gallbladder is now removed using a standard laparoscopic approach. R3 retracts the gallbladder cephalad towards the right shoulder, and dissection proceeds in the triangle of Calot using the robotic hook to establish the critical view of safety. The cystic duct and artery are doubly clipped and divided. The gallbladder is resected off its beds using the robotic hook cautery.
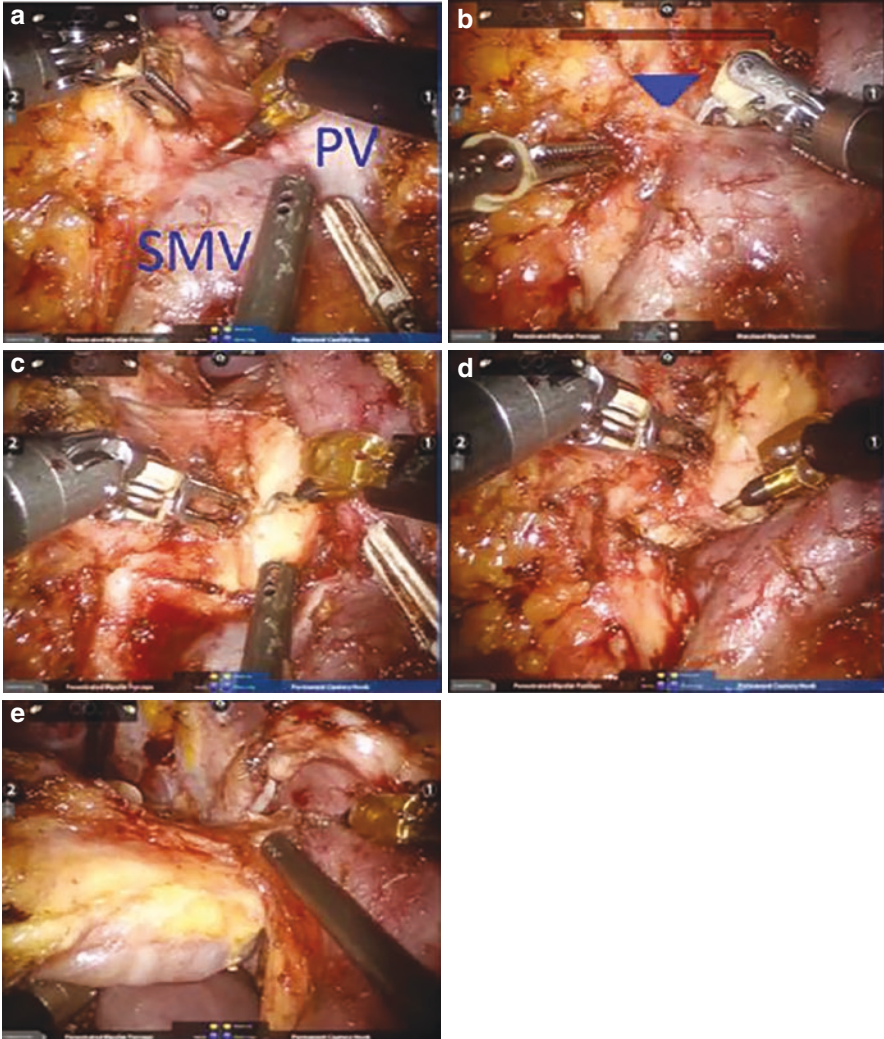
Fig. 16.6 Uncinate dissection and the superior mesenteric artery (SMA) layer: the entire uncinate process is removed with the specimen ensuring adequate retroperitoneal margin. A hook monopolar cautery in R1 divides these attachments and the small venous tributaries are controlled with LigaSure along the way (**a**). This step is carried through until the superior pancreaticoduodenal vein of Belcher (blue arrowhead) is reached (**b**) and controlled with LigaSure. During these steps, it's imperative to apply adequate traction on the specimen in the "up & out" direction. With the SMV and first jejunal vein retracted medially, the plane of Leriche is accessed (**c**). Dissection right along the SMA proceeds in systemic manner until the inferior pancreaticoduodenal artery is reach, dissected at its based and controlled with LigaSure and/or clips (**d**). The final attachments are divided with LigaSure

Both specimens (Whipple and gallbladder) are placed in a 15-mm endoscopic retrieval bag and removed from the 12-mm assistant trocar incision. This necessitates extending it slightly by 3–4 cm. Once the specimen is removed, a gel port (GelPoint Applied Medical, Rancho Santa Margarita, CA) is applied to maintain insufflation pressures. The 12-mm trocar is placed through the gelport. The specimen is sent for frozen margin assessment for the pancreatic and CBD/CHD margins, if deemed necessary by the surgeon.

Troubleshooting *Beware of bleeding from the left inferior epigastric as the LLQ is extended. We recommend placing the initial 12 mm port just lateral to the inferior epigastric artery and extending the incision laterally to avoid injuring this blood vessel.*

16.4.4   Reconstruction Phase

As mentioned previously in Sect. 16.4.3.1. a "neo-tunnel" is created after the division of the ligament of Treitz. The jejunal limb is brought up to the RUQ through this tunnel behind the root of mesentery and should lay comfortably with the antimesenteric border facing the transected pancreatic neck stump. The allows reconstruction of pancreatic and biliary anastomoses without undue tension.
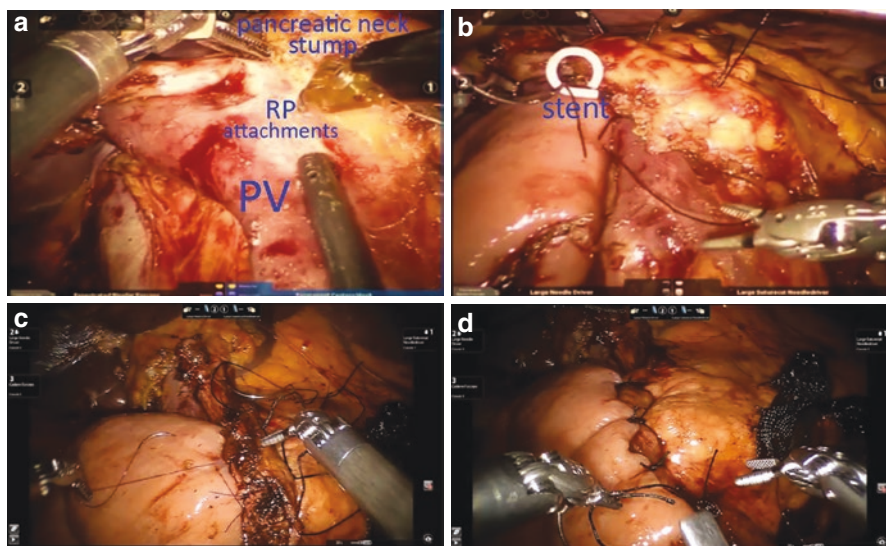
16.4.4.1   Pancreaticojejunostomy

The pancreaticojejunostomy is performed in an end-to-side, duct-to-mucosa fashion using a modified Blumgart technique. First, the duct is cannulated with a size 4 or 5 French Hobbs ERCP stent (Hobbs Medical, Stafford Springs, CT) to prevent inadvertent narrowing. This is especially important if the duct is of narrow caliber (<3 mm). The pancreatic neck stump is mobilized from its retroperitoneal attachments for approximately 1–2 cm. This will allow the loop of jejunum to lay firmly under the pancreas and 'buttress' the posterior layer. Three interrupted 2-0 silk mattress sutures (each cut to 8 cm of length) are taken full-thickness through the pancreas (anterior surface to posterior surface), horizontally through the seromuscular layer of the jejunum, then back again through the pancreas from posterior to anterior, completing the U-stitch configuration. Two are taken at the superior and inferior edges, and a middle one straddles the duct. The sutures are then tied down to ensure complete opposition between the jejunal loop and the mobilized posterior surface of the pancreas. To facilitate this process, the most superior suture is kept under traction by the Prograsp R3. The needles are kept in situ after completing this step, since they are used to perform the anterior seromuscular layer later on. Hobbs stent mobility is checked to ascertain the duct is not narrowed by the middle straddle suture.

After the outer posterior layer of the anastomosis is constructed, the duct-to-mucosal inner layer is performed. An enterotomy is first made using a single jaw of the robotic endoshear on the antimesenteric border of the jejunal loop. Using 5-0 polydioxanone suture (Ethicon, Cincinnati, OH), 2 interrupted bites are taken posteriorly "in-out" through the duct, and then "out-in" full thickness through the bowel wall. These are tied (knots on the inside), and the stent is then placed into the jejunum. The anterior sutures (4–6 as needed) are now placed circumferentially in the same manner, but "out-in" full-thickness through the bowel then "in-out" through the duct (knots on outside) completing the inner layer. The anterior sutures are tied only after all of the sutures are placed under direct vision to ensure duct to mucosa sutures and inadvertent suturing of the indwelling stent.

After inner duct to mucosa layer is completed, the silk suture originally used to construct the posterior layer of the anastomosis, will now be used to complete the outermost layer in an interrupted Lembert fashion. At the end, the jejunum should completely encompass and cover the transected pancreatic stump (Fig. 16.7).

Troubleshoot *Caution is advised when taking the 2-0 U stitches through the pancreas, as this could inadvertently narrow the pancreatic duct, particularly with a soft gland and small caliber (<3 mm) duct. Placement of the Hobbs stent allows the surgeon to 'gauge' the direction of the duct and ensure that it is not violated. After tying these sutures firmly, easy mobility of the Hobbs stent should be interrogated.*

Fig. 16.7 Pancreaticojejunostomy. Mobilization of the pancreatic neck stump from its retroperitoneal attachments is first accomplished with hook monopolar cautery (**a**). After cannulating the pancreatic duct with a 4- or a 5- French ERCP stent, three modified Blumgart sutures are placed to create the posterior layer of the anastomosis (**b**). An enterotomy is then created, and the inner layer of the anastomosis is fashioned in a duct-to-mucosa fashion. The final layer of the anastomosis is complete using the originally placed silk sutures taken in a Lembert fashion (**c, d**)
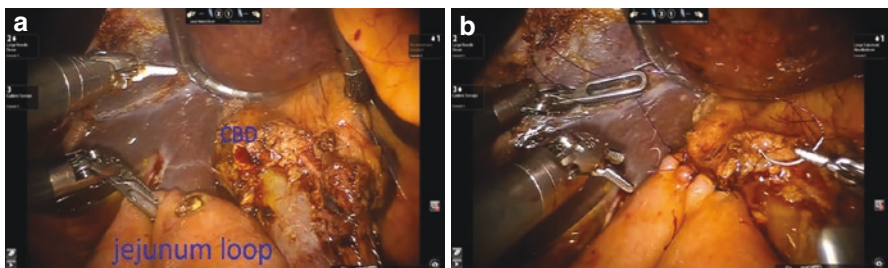
16.4.4.2   Hepaticojejunostomy

The technique for construction of the hepatoeneteric anastomosis is also in an end-to-side fashion on the antimesenteric border of the jejunal loop that lies comfortably adjacent to the transected common bile/hepatic duct. It is prudent to always construct the hepaticojejunostomy about 10 cm distal to the Pancreaticojejunostomy. This extra distance has the theoretical advantage of minimizing biliary spillage from an adjacent pancreatic leak.

The mode of reconstruction depends on the size of the duct. If the duct is small (<8 mm) or has thin walls, the anastomosis is constructed using 5-0 PDS sutures in an interrupted fashion with a Hobbs stent placed across the anastomosis. In a large duct (>8 mm), the anastomosis can be performed using two running 4-0 V-Loc 180 green sutures (Covidien-Medtronic, Minneapolis, MN).

The staple line across the duct is cut sharply to ensure bleeding. The bile is suctioned, and spillage is avoided. Again, an enterotomy is made using a single jaw of the robotic shears, but care should be made to avoid enlarging the enterotomy beyond the size of the common hepatic or bile duct, since eventual manipulation almost always increases the size of the enterotomy.

Regardless of the technique of construction, the posterior layer is performed first, taking full thickness bites "in-out" through the duct, then "out-in" through the jejunal loop. The starting point is the most lateral edge on the right and proceeds medially. If continuous suturing is being performed, both V-Loc sutures are secured at the most lateral edge of the anastomosis and proceed in opposite directions. Gentle traction of the anterior sutures using cadiere or prograsp in R3 is again needed. Once the anterior and posterior layers overlap, they are tied completing the hepaticojejunostomy (Fig. 16.8).

Troubleshooting   *If viability of the CHD is in question, then a more proximal transection margin could be selected. If a point where the right and left hepatic duct diverge is reached, a side-to-side ductoplasty can be performed, which is then anastomosed to a single jejunal enterotomy in an end-to-side fashion.*

Fig. 16.8 Hepaticojejunostomy. If the CBD is adequate in caliber, the anastomosis can be constructed in a continuous running fashion using 4-0 V-Loc sutures. The first suture is taken at the lateral most aspect of the duct, and traction is applied on this suture using R3 until the posterior layer of the anastomosis is complete (**a**), the same is carried out for the anterior layer. If the duct is small in caliber, the anastomosis is complete in an interrupted fashion for the posterior and anterior layers (**b**)
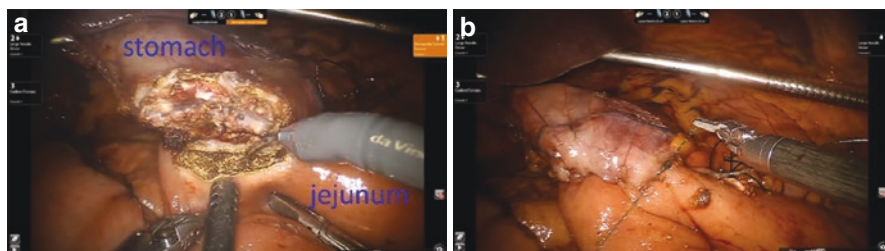
16.4.4.3 Gastrojejunostomy

The distal end of the jejunal loop used as the "neo-duodenum" should be marked to differentiate the efferent and afferent limbs. We place a double long suture to denote proximal (afferent) and single long for distal (efferent). These markings should be made around 30–40 cm distal to the hepaticojejunostomy.

Next, the transverse colon and its mesentery are retracted cephalad, while the "excess" jejunum is reduced until the marking sutures are identified. This is a fundamental step for the proper orientation of the gastrojejunostomy and prevents twisting of the bowel. This is a difficult step to accomplish robotically and requires careful coordination between the console surgeon and the bedside assistant. The preselected loop of jejunum is brought up in an ante-colic fashion to construct an end-to-side, two-layered, isoperistaltic gastrojejunostomy. First, the posterior layer is completed using a series of interrupted 2-0 silk sutures in Lembert configuration. R3 grasps and retracts the corner stitch (at the lesser curve) for adequate exposure. Using the robotic "hot" scissors, around 6 cm of the gastric staple line is then removed, starting at the greater curvature proceeding towards the lesser curvature. An equivalent enterotomy is made. The interior layer of the anastomosis is completed using two 3-0 V-Loc 180 green sutures (Covidien-Medtronic, Minneapolis, MN) starting at each corner. The posterior aspect of the internal layer is completed in a continuous simple fashion, while the anterior layer is performed with a running Connell stitch. The sutures are tied when they overlap. Finally, the anterior layer of the anastomosis is completed using several interrupted 2-0 silk sutures taken in an interrupted Lembert fashion (Fig. 16.9).

Troubleshoot *The gastrojejunostomy can be performed in a side-to-side isoperistaltic stapled manner, but in a study from our institution comparing handsewn to stapled technique, our data demonstrated an increased risk of postoperative delayed gastric emptying using the stapled technique* [10].

Fig. 16.9 Gastrojejunostomy: constructed in a two layered end-to-side fashion (**a**). The inner posterior layer is completed with a 3-0 V-Loc running stitch. When the last corner stitch is taken, transition to a running Connell stitch to complete the anterior layer of the anastomosis is performed (**b**)

16.4.5 Drain Placement, Closure

At the end of the procedure, a single 19F Blake drain is placed through the R3 trocar incision site. It is positioned posterior to the hepaticojejunostomy and anterior to pancreaticojejunostomy and attached to bulb suction. If the operating surgeon deems it necessary, the stump of the GDA can be covered with a vascularized tissue flap constructed from the round ligament. The SI or XI robot is undocked and the trocars are removed under vision. The fascia of the 12-mm trocar (SI) and the extraction site are closed with #1 polysorb sutures in an interrupted fashion.

16.5 Postoperative Management

Unless the patient's status requires intensive care monitoring, the majority of patients are transferred to a monitored surgical floor postoperatively and enrolled in an enhanced recovery pathway (ERAS). The nasogastric tube is removed shortly after the patient is transferred to the surgical ward or on postoperative day (POD) 1. Clear liquid diet can be started on the day of the operation or POD 1 and is advanced as tolerated to low residue diet by POD 5–6. The drain output and amylase levels are monitored daily and early drain removal is advocated. If the amylase level on POD 1 is <5000 IU/ml and continues to trend down, the drain can be removed on POD 3–5. Patients are generally discharged on POD6.

16.6 Conclusion

Robotic pancreaticoduodenectomy at the University of Pittsburgh is a complex procedure consisting of several well-defined steps. It requires a fundamental understanding of the principles of open pancreatic surgery, proper patient selection, and coordination between the console and bedside surgeon. Our methodological approach to this demanding operation has resulted in a safe and oncologically effective operation. In recent years, our team has shown the ability to disseminate our technique and approach to other adopters.

Conflict of Interest The authors have no conflict of interest to declare.

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