Chapter 59
Robotic-Assisted Pancreatic Surgery for Pancreatic Cancer: Technical Aspects

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Take Home Messages
- Appropriate patient selection, especially in the early phase of a robotic pancreas program, is paramount to achieve optimal outcomes.
- Adequate training, close coaching and the use of two-faculty approach is necessary to build a successful program.
- Published data on the safety, feasibility and oncologic outcomes mainly emanates from high volume centers. Therefore, cautious use and interpretation of these data is advisable when starting a program.

Pearls and Pitfalls
- Expertise in both pancreatic and robotic surgery is needed to establish a successful robotic program.
- Conversion to open surgery in the setting of hemorrhage should be prompt and requires impeccable coordination between operating surgeons and operating room staff. Injury to the portal vein and its tributary system can often be controlled by compression of the vessel with a laparoscopic instrument and a gauze. This maneuver permits to undock the robotic platform in a controlled fashion and to gain undisturbed access to the abdomen for a laparotomy.

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Future Perspectives

- Randomized trials are needed to ascertain the safety and oncologic efficacy of robotic pancreatic surgery in comparison to the open approach.

59.1 Introduction

The use of robotic surgery has been widely adopted in many surgical procedures but its application in pancreatic resection for cancer has lagged due to the complexity of the operation, the high morbidity of the surgery and the concern of inferior oncologic outcomes (Table 59.1). Over the last decade, multiple studies showed that robotic pancreatic surgery is safe, feasible, and has at least equivalent morbidity profile and oncologic outcomes compared to open surgery [1–14].

In 2019, the Miami international evidence-based guidelines on minimally invasive pancreas resection were published and supported the use of minimally invasive distal pancreatectomy for pancreatic ductal adenocarcinoma and low-grade malignant tumors but acknowledged that there is insufficient data to recommend minimally invasive pancreaticoduodenectomy (PD) over the open approach [15].

In our institution, we created a program to optimize the robotic approach for PD starting 2008. First, we focused on understanding the safety and feasibility of the procedure. This was followed by studies on the optimal learning curve which is

Table 59.1 Outcomes Table comparing RPD to OPD/LPD and RDP to ODP/LDP

Author	Year	Approach	Number	Mortality (%)	Major morbidity (%)	LOS (days)	OT (min)
Zureikat et al. [6]	2016	RPD vs. OPD	211 vs. 817	1.9 vs. 2.8[b]	23 vs. 23	8 vs. 8[a]	402 vs. 300[c]
Kowalsky et al. [1]	2019	RPD vs. OPD	159 vs. 95	4 vs. 6[b]	26 vs. 33	7 vs. 8[a]	371 vs. 413[c]
Nassour et al. [14]	2017	RPD vs. LPD	193 vs. 235	1 vs. 2.6	55 vs. 49	11 vs. 11	422 vs. 429
Nassour et al. [11]	2017	RPD vs. LPD	165 vs. 1458	4.8 vs. 5.6[b]		9 vs. 8[a]	
Lee et al. [16]	2014	RDP vs. ODP	37 vs. 637	0 vs. 0.6[b]	43 vs. 25	5 vs. 7[a]	213 vs. 185[c]
Magge et al. [2]	2018	RDP vs. ODP	196 vs. 85	0 vs. 3.5[c]	14 vs. 21	6 vs. 8[a]	211 vs. 316[c]
Daouadi et al. [10]	2013	RDP vs. LDP	30 vs. 94	0 vs. 1.1[b]	20 vs. 14	6 vs. 7	293 vs. 372[c]
Raoof et al. [17]	2018	RDP vs. LDP	99 vs. 605	0 vs. 3[b]		5 vs. 6[a]	

RPD robotic pancreaticoduodenectomy, *OPD* open pancreaticoduodenectomy, *LPD* laparoscopic pancreaticoduodenectomy, *RDP* robotic distal pancreatectomy, *ODP* open distal pancreatectomy, *LDP* laparoscopic distal pancreatectomy, *LOS* length of stay, *OT* operative time

[a]Median Length of Stay (LOS). Otherwise, the values represent mean LOS

[b]90 days mortality. Otherwise, the values represent 30-day mortality

[c]$P < 0.05$

estimated at 80 cases for novice adopters and then we performed multiple comparative studies which supported the efficacy of the robotic approach. Finally, we developed a training program that allows safe propagation of this technique.

In this chapter, we will focus on the technical aspects of robotic pancreaticoduodenectomy (RPD) and distal pancreatectomy (RDP) with or without en bloc resection of the celiac axis.

59.2 Patient Selection for Robotic Pancreatic Surgery

The indication for robotic pancreatic surgery is similar to open approach with few exceptions. Selecting patients adequately, especially in the early learning curve is important to the success of the procedure. Here are key considerations:

(a) Optimal pathology to undergo RPD is small pancreatic adenocarcinoma with pancreatic and biliary duct obstruction. The large size of the ducts and firm texture of the pancreas allow easier reconstruction for novice. Once the surgeon becomes more experienced, the application of this approach may be expanded to other periampullary malignancies.
(b) All patients need high quality triphasic computed tomography scan to determine the relationship of the tumor to the vasculature. Patients who require vascular reconstruction should not undergo robotic surgery—at least for the time being.
(c) Patients with biopsy proven pancreatic body/tail tumor with involvement of any branches of the celiac axis should have a disease-free hepatic trunk and gastroduodenal artery (GDA) to be able to perform a distal pancreatectomy with en bloc resection of the celiac axis.
(d) Patients with extreme BMI (i.e. ≥40 or ≤20) should not be offered robotic surgery: Patient with low BMI or with small transverse diameter will not have adequate working space for the robotic instruments. On the other hand, patients with high BMI pose a challenge in the mobilization of the transverse mesocolon and the division of the ligament of Treitz from the right upper quadrant.
(e) Since the robotic approach usually takes longer time than the open one, a patient who underwent previous abdominal surgery and has extensive adhesions requiring significant lysis should only rarely if ever be selected for this approach. In addition, a patient with upper gastrointestinal reconstructions should be avoided due to the difficulty of small bowel orientation robotically and the concern of small bowel injury during excessive manipulation due to lack of haptic feedback.

59.3 Robotic Pancreaticoduodenectomy

The patient is positioned on the split-leg table with the legs abducted to allow for the assistant to stand in between the legs. The right arm is tucked, and the left arm is placed on an arm board. The operative table is placed in steep Trendelenburg and rotated 45° away from the anesthesia-related space to allow for the Da Vinci® Si robot to be docked at the head of the table. If the Xi is used, the robot can be docked from the side of the patient.

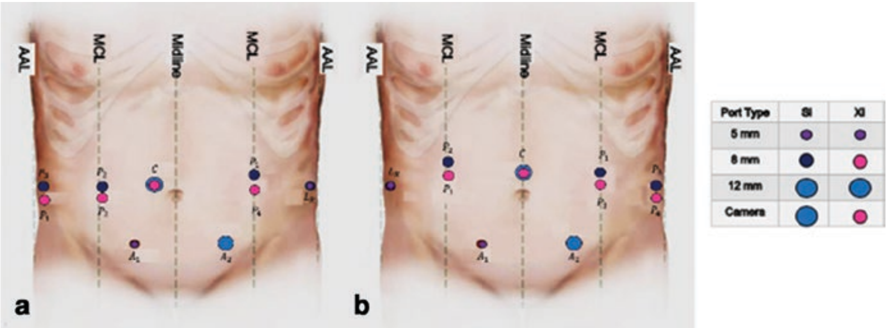

Fig. 59.1 Trocar placement for (**a**) Whipple. (**b**) Distal pancreatectomy

The abdomen is accessed via an incision in the left upper quadrant along the midclavicular line and 3 cm above the umbilicus using a 5 mm zero-degree scope and an optical separator trocar. After insufflation to 15 mmHg, a diagnostic laparoscopy is performed to rule out metastasis and then 6 additional ports are placed as described per Fig. 59.1a. Briefly, the camera 12 mm laparoscopic port is placed 3 cm above and to the right of the umbilicus (note that a 12 mm camera port applies to the DaVinci Si platform only, all Xi ports- including the camera port- are 8 mm). Two 8 mm robotic trocars are placed in the right abdomen in the mid-clavicular (P2) and anterior axillary (P3) line at the same level as the camera. Then, the optical separator–which was used to access the abdomen– is changed to an 8 mm robotic trocar (P1). A 5-mm assistant port is placed a handbreadth below and between the camera and P2, and another 12-mm assistant port is placed a handbreadth below and between the camera and P1. The last 5-mm trocar—through which the Mediflex liver retractor is introduced—is placed laterally just inferior to the left costal margin.

After docking the robot, the resection portion of the operation— which consists of 4 major steps— starts (see Video 59.1).

59.3.1 Right Colon Mobilization, Kocherization and Division of the Ligament of Treitz

Using the hook cautery and the fenestrated bipolar, the gastro-colic ligament is taken down to access the lesser sac inferior to the right gastroepiploic vessels. The stomach is retracted anteriorly with a Prograsp through P3 and all adhesions between the stomach and the pancreatic capsule are taken down. The transverse mesocolon is dissected inferiorly, then the hepatic flexure and right colon are mobilized to expose the duodenum. After kocherization, the ligament of Treitz is divided from the patient's right side and the duodenum is completely freed up allowing for the proximal jejunum to be delivered in the right supracolic compartment. The proximal jejunum is transected 10 cm from the duodenum with a GIA

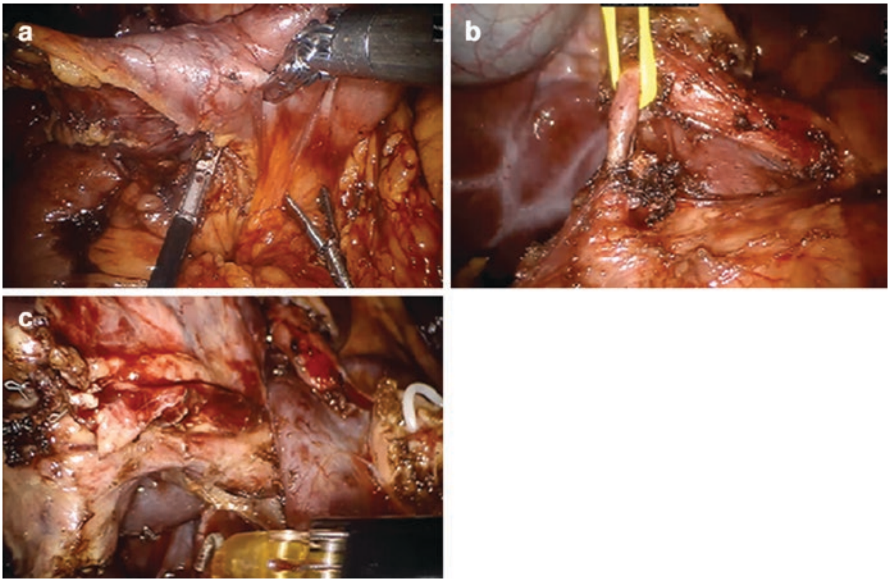

Fig. 59.2 (**a**) After kocherization, the ligament of Treitz is divided, and the jejunum is delivered into the right upper quadrant allowing to linearize the duodenum. (**b**) Dissected GDA. (**c**) Exposed SMV/PV after transection of the pancreas

stapler using a 60 mm gold staple load. The mesentery is divided with the Ligasure™ up to the uncinate process, therefore creating a linearized segment of duodenum (Fig. 59.2a).

59.3.2 Dissection of the Porta-Hepatis

The gastrohepatic ligament is divided with care taken not to injure a replaced or accessory left hepatic artery. Then the stomach is divided with a GIA stapler using a 60 mm purple load exposing the porta hepatis. The station 8A lymph node is dissected off the common hepatic artery and the right gastric artery is doubly clipped with a 5-mm Endo Clip and divided. Using a no touch technique, we dissect the common hepatic artery (CHA), gastroduodenal artery (GDA) and the portal vein (PV). The GDA is circumferentially dissected and transected with a GIA stapler using a 45-mm gold load after confirming that there is still pulse in the hepatic artery when the GDA is clamped (Fig. 59.2b). Then, the common bile duct is dissected circumferentially and off the PV using the robotic monopolar hook cautery and is transected with a GIA stapler with angled tip using a 45 mm gold load to avoid bile spillage. Finally, we dissect along the anterior border of the PV heading inferiorly toward the neck of the pancreas to facilitate creating the retropancreatic tunnel.

59.3.3 Creation of Retropancreatic Tunnel and Transection of the Pancreas

The duodenum is retracted toward the right upper quadrant (P3) creating tension on the gastroepiploic vein. Attention is now directed to the SMV which must be identified at the infra-pancreatic border–by a combination of gentle brushing and energy dissection—and then dissected along its anterior surface, using the hook cautery. Thus, we identify the right gastroepiploic vein, middle colic vein and the trunk of Henle which is divided using the Ligasure™. Then, the retropancreatic tunnel is developed by elevating the pancreas with the fenestrated bipolar and gently pushing down on the SMV with the hook. The neck of the pancreas is then divided with hot monopolar shears until the duct is encountered. The duct is sharply divided to prevent thermal injury (Fig. 59.2c).

59.3.4 Dissection of the Uncinate

The specimen is retracted laterally (using P3 which holds the inferior stapled edge of the transected D1) to expose the uncinate and the small fibers between the uncinate and the SMV/PV are divided. The vein of Belcher is transected superiorly with the Ligasure™. and the first jejunal vein is preserved inferiorly. Then the dissection is continued along the SMA and the inferior pancreaticoduodenal artery is divided. Finally, the retroperitoneal tissue to the right and behind the SMA is resected with the Ligasure™. After performing a cholecystectomy, the specimen is placed in a 15-mm EndoCatch retrieval bag and removed through the LLQ Incision after extending it to 4 cm. A gel port is placed in the extraction site and pneumoperitoneum is re-established in preparation for the reconstruction phase which consists of 3 additional steps (see Video 59.2).

59.3.5 Pancreaticojejunostomy

A modified Blumgart technique is performed for the pancreaticojejunostomy anastomosis (Fig. 59.3a). The pancreatic neck is dissected off the retroperitoneum and the anterior surface of the splenic vein for 1 cm to allow space for the jejunum to oppose firmly to the pancreas. The jejunum is brought behind the root of the mesentery as a neo-duodenum with the antimesenteric border facing the transected edge of the pancreas. Three horizontal mattress sutures (2-0 silk cut to 20 cm) are placed. We start anteriorly on the surface of the pancreas, full thickness through the gland, then we take a horizontal seromuscular bite of the jejunum and finally we go back through the pancreas from posterior to anterior. A 4- or 5- French stent is placed in the duct to prevent narrowing from the second stitch which is placed around the pancreatic duct. The sutures are tied and the needles are left to be used for the anterior seromuscular layer. The straddling suture around the pancreatic duct is tied loosely to approximate the posterior pancreatic capsule to the jejunal serosal layer but without exerting any external compression on the pancreatic duct. After tying this suture, the pancreatic stent is completely removed from the pancreatic duct and reinserted to ensure patency of the pancreatic duct.

Next, a duct to mucosa anastomosis is performed. After performing an enterotomy on the antimesenteric border of the jejunum directly facing the pancreatic duct, interrupted 5-0 polydioxanone sutures are placed. Posteriorly, two to three sutures are placed and tied. The stent is placed back in the pancreatic duct and into the jejunum. Then anterior sutures are placed to complete the anastomosis. These sutures are tied at the end to allow better visualization of the anastomosis. Finally, the 2-0 silk are used to complete the anterior outer layer by taking seromuscular bites of the jejunum.

59.3.6 Hepaticojejunostomy

An end-to-side hepaticojejunostomy is performed either in a continuous fashion for a large duct (>8 mm) or in an interrupted fashion for a small duct (<8 mm) and a stent is placed.

We sharply cut the bile duct staple line to ensure bleeding and we create an enterotomy in the jejunum slightly smaller than the bile duct, 10 cm distal to the pancreaticojejunostomy. For continuous anastomosis, we use two 4-0 V-loc sutures from the right lateral edge to medially. First the posterior raw is performed and then the anterior one until both overlap. Finally, both sutures are tied together.

For interrupted anastomosis, we use 5-0 polydioxanone or 5-0 polyglyconate sutures (Fig. 59.3b). After placing a right corner stitch and retracting it to expose the anastomosis, we start placing sutures posteriorly and tying them down. Then the anterior raw of sutures is placed laterally to medially without tying them initially to maintain good visualization of the anastomosis. At the end, the sutures are tied down and the anastomosis is completed.

59.3.7 Gastrojejunostomy

The jejunum is marked 40 cm distal to the hepaticojejunostomy with 2 sutures to be able to identify the correct orientation. Then the transverse colon is retracted cephalad to find the divided ligament of Treitz. The excess jejunum is reduced through the defect and it is brought up in an antecolic fashion to perform a 2-layer end-to-side hand-sewn isoperistaltic gastrojejunostomy (Fig. 59.3c). The stomach is grasped along the lesser curvature with P3 and moved medially and superiorly toward the left lateral sector of the liver, this maneuver creates appropriate tension and

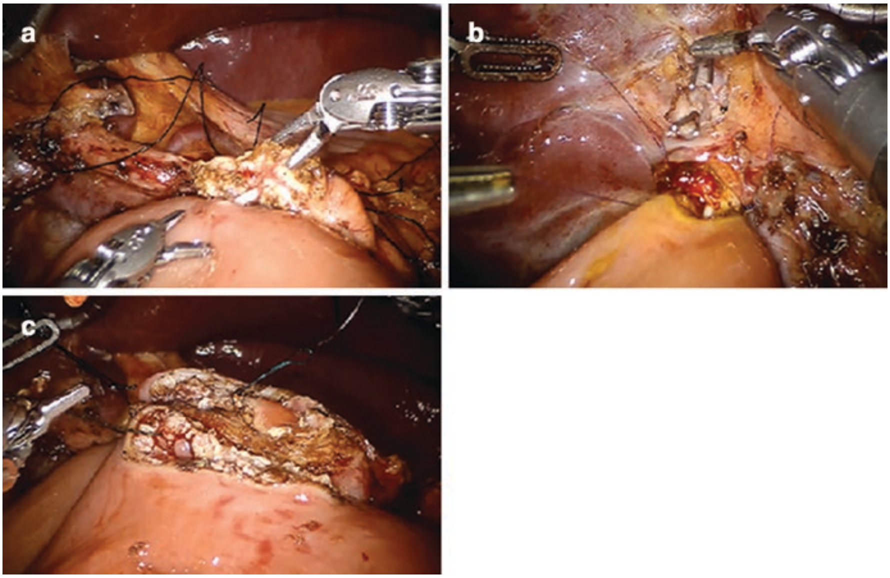

Fig. 59.3 (**a**) Pancreaticojejunostomy. (**b**) Hepaticojejunostomy. (**c**) Gastrojejunostomy

facilitates exposure. The posterior raw is created using 2-0 silk interrupted Lembert sutures. The robotic monopolar curved scissor is used to cut 4 cm of the gastric staple line and to create an enterotomy. Two 3-0 V-loc are used to create the inner layer. The posterior layer is performed in a continuous fashion while the anterior one is done using a running Connell stitch. Finally, the outer layer is completed with interrupted 2-0 silk Lembert sutures.

At the end of the procedure, a 19-French channeled drain is placed posterior to the hepaticojejunostomy and anterior to the pancreaticojejunostomy through the P3 trocar and the fascia of the extraction site and the 12 mm trocar are closed with #1 Polysorb sutures. Postoperatively, the patient management follows the enhanced recovery pathway.

59.4 Robotic Distal Pancreatectomy

Similar to robotic pancreaticoduodenectomy, the patient is positioned on a split-leg table with the legs abducted. The left arm tucked, and the right one is placed on an arm board. The operative table is placed in steep Trendelenburg and rotated 45 degrees away from the anesthesia to allow for the Da Vinci® SI robot to be docked at the head of the table. If the XI is used, the robot can be docked from the side of the patient.

The abdomen is accessed via an incision in the left upper quadrant along the midclavicular line using a 5 mm zero-degree scope and an optical separator trocar. After performing a diagnostic laparoscopy to rule out metastatic disease, 6 additional ports are placed. The robotic ports are placed in a mirror image to the

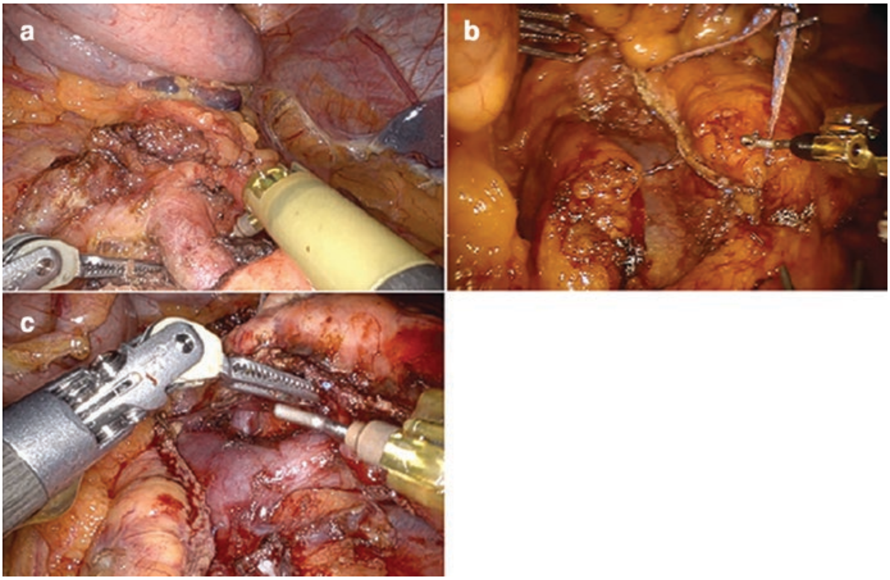

Fig. 59.4 (**a**) The dissected splenic artery. (**b**) After transection of the pancreas, the umbilical tape can be used as a handle to retract the gland. (**c**) Splenic vein dissected circumferentially

pancreaticoduodenectomy—as depicted in Fig. 59.1b—while the assistant ports are positioned in a similar fashion.

We perform the initial part of the operation laparoscopically. The lesser sac is opened by taking down the gastrocolic ligament with the Ligasure™ making sure to preserve the right gastroepiploic vessels. Then the short gastric vessels are divided to fully expose the pancreas. Next, we mobilize the left and transverse colon by taking down the white line of Told, the splenocolic and splenorenal ligaments. At this point, the liver retractor is placed under the stomach to allow for a good visualization of the celiac axis and the pancreas. The robot is docked. Next, the splenic artery is dissected circumferentially, and a vessel loop is used to encircle the artery (Fig. 59.4a). A bull-dog is used to occlude the vessel and confirm that there is flow to the hepatic artery. Usually the left gastric vein is encountered during the splenic artery dissection and is divided with the Ligasure™. The splenic vein is dissected at the inferior border of the pancreas, encircled with a vessel loop and finally a tunnel is created behind the pancreas. An umbilical tape is placed around the pancreas, this will serve as a handle to facilitate pancreatic parenchymal engagement with the stapler which is fired using a 60 GIA purple load (Fig. 59.4b). Then, using a 45 GIA gold load with a curved tip, the artery is divided followed by the vein (Fig. 59.4c). While holding the staple line of the specimen and retracting it anteriorly, the attachments of the pancreas to the retroperitoneum are divided using the Hook cautery. Finally, the spleen is mobilized by dividing its suspending ligaments and the pancreas-spleen unit is extracted through the left lower quadrant 12-mm port incision.

At the end of the procedure, a 19-French channeled drain is placed through the P1 trocar and the fascia of the extraction site and the 12 mm trocar are closed with

#1 Polysorb sutures. Postoperatively, the patient management follows the enhanced recovery pathway.

59.5 Robotic Distal Pancreatectomy with En Bloc Resection of the Celiac Trunk (DP-CAR)

Patient position and port placement are similar to robotic distal pancreatectomy (Fig. 59.1b). Similarly, the lesser sac is entered, and the left/transverse colon is mobilized. The stomach is then retracted to expose the neck and the body of the pancreas. The common hepatic artery (CHA) is followed along the superior border of the pancreas to identify the GDA. Then the CHA is clamped and blood flow in the proper, right and left hepatic arteries is confirmed using the robotic ultrasound. If there is a triphasic flow in these vessels, the operation can proceed in a robotic fashion. If not, then we convert to an open procedure as this scenario will require a jump graft from the aorta to the proper hepatic artery.

The splenic artery is identified and transected at the tail as the proximal part is usually encased by the tumor, then the splenic vein is divided followed by the pancreatic parenchyma to the left of the GDA.

The CHA artery is transected while preserving the GDA origin (Fig. 59.5a). Then it is followed proximally to the left gastric vessels which are transected then to the celiac axis. At this point the aorta is exposed superior to the celiac trunk and inferiorly until the SMA is exposed posterior to the pancreas. The location of the SMA and celiac axis are confirmed with the robotic ultrasound. After clearing all lymphatics and perineural tissues surrounding the aorta and celiac axis, the origin of the celiac axis is transected using a stapler (GIA 45 mm gold vascualr load) (Fig. 59.5b). Finally, the specimen is extracted through the left lower quadrant 12-mm port incision.

At the end of the procedure, a 19-French channeled drain is placed through the P1 trocar and the fascia of the extraction site and the 12 mm trocar are closed with #1 Polysorb sutures. Postoperatively, the patient management follows the enhanced recovery pathway.

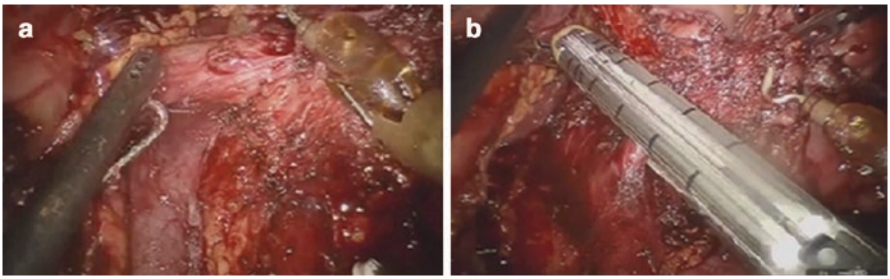

Fig. 59.5 (**a**) Common hepatic artery exposed and ready to be transected with care taken to protect the GDA. (**b**) Transection of the celiac artery at its base

59.6 Miscellaneous Robotic Pancreatic Surgery

The robot can be used for any pancreatic operation as long as the surgeon has an adequate expertise in pancreatic procedures and in using the robotic platform. We have previously described how to use the robot to perform:

1. Cyst-gastrostomy with debridement of infected necrotic pancreatic tissue and continued drainage into the stomach.
2. Total pancreatectomy with or without auto islet transplantation for chronic pancreatitis.
3. Puestow, Frey and Beger procedures for chronic pancreatitis.

59.7 Conclusion

In conclusion, the robotic platform can be safely and effectively used to perform a wide variety of pancreatic procedures in the hands of experienced and high-volume surgeons. Training in expert centers with a formalized curriculum is important to start a successful robotic pancreatic program and can potentially help to decrease the challenges encountered during the early adaption phase.

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4. (02:01–02:03) Division of the ligament of Treitz
5. (02:04–02:09) Jejunal transection
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3. (03:15–03:36) Pancreaticobiliary limb identification and marking
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