# 13 Robotic Pancreaticoduodenectomy (Whipple Procedure)

Martin J. Dib, Tara Kent, and A. James Moser

## Introduction

The major technical aspects of pancreatoduodenectomy (PD) to resect tumors of the periampullary region have not changed significantly since it was first established in the early twentieth century. Allen O. Whipple published the first case series of a single-stage PD in 1945, and Traverso and Longmire described the addition of pylorus preservation in 1978 [1, 2]. The high postoperative mortality rates prevented the widespread use of PD for several decades, but advancements in critical care, anesthesia, and attention to surgical detail led to significant outcome improvements [3, 4]. The most recent refinements have focused on minimally invasive adaptations, taking the advantages of technological innovations in complex resections and anastomotic reconstructions.

The first laparoscopic PD was published by Gagner and Pomp in 1994 [5]. Reports of totally laparoscopic PDs have been published by Palanivelu et al. [6] and Kendrick and Cusatti [7], although less than 200 reports of laparoscopic PDs are found in the English literature since Garner's first description. The slow adoption of laparoscopic PDs is a result of the technical burdens and complexity of this procedure [8].

Robotic-assisted surgery, with magnified stereoscopic visualization and computer-enhanced 540° movement of the surgical instruments, has the potential to overcome the technical impediments to recreating time-tested techniques for open pancreatic surgery in a minimal access technique. Variations of robotic-assisted PD and its preliminary outcomes have been published by groups led by Giulianotti, Melvin, and Moser and Zeh [9–15].

## Selection Criteria

Selection criteria for attempting minimally invasive resection for pancreatic cancer are of equal importance to the technical aspects and must address potential oncological hazards including the likelihood of residual tumor at the surgical margin and adequacy of lymph node sampling. We select patients for robotic-assisted PD (RAPD) using a validated predictive model to maximize the likelihood of R0 surgical resection among patients with pancreatic cancer [16]. Three factors are evaluated: evidence for any vascular involvement on preoperative CT scan, abnormal lymph nodes on endoscopic ultrasound (EUS), and tumor

M.J. Dib, M.D. • T. Kent, M.D., F.A.C.S.
Department of Surgery, Beth Israel Deaconess Medical Center, 330 Brookline Avenue, Stoneman 9th Floor, Boston, MA 02215, USA
e-mail: mdib@bidmc.harvard.edu; dibmartin@gmail.com; tkent@bidmc.harvard.edu

A.J. Moser, M.D., F.A.C.S. (✉)
Institute for Hepatobiliary and Pancreatic Cancer, Beth Israel Deaconess Medical Center, 330 Brookline Avenue, Boston, MA 02215, USA
e-mail: jmoser1@bidmc.harvard.edu

K.C. Kim (ed.), *Robotics in General Surgery*, DOI 10.1007/978-1-4614-8739-5_13,

diameter greater than 2.6 cm on EUS. RAPD is offered only to patients at low-predicted risk of a non-R0 outcome: (a) EUS stage 1A; (b) absence of vascular involvement on CT and EUS stage less than or equal to 2A; and (c) absence of vascular involvement on CT and EUS stage 2B, but largest tumor diameter <2.6 cm.

## Position, Equipment, and Trocar Placement

The patient is positioned supine on a split-leg table with the right arm tucked and the left arm extended, and the robot is docked from straight over the patient's head. Seven laparoscopic ports are required (Fig. 13.1a, b). A 5-mm optical separator is used to access the peritoneal cavity in the left subcostal region. The camera port is placed 2–3 cm superior and to the right of the umbilicus to improve exposure of the portal vein. Two 5-mm ports are placed in the right upper quadrant and later converted to 8-mm robotic trocars. A 5-mm port for the laparoscopic liver retractor is inserted in the anterior axillary line. Two assistant ports are placed in the lower quadrants. Once resectability is ensured, a 5-cm extraction incision is created and sealed with a GelPoint® access device, through which a 10-mm port is inserted for the passage of needles, staplers, and extraction bags.

## Step 1: Mobilization of the Right Colon and Pancreatic Head

Following laparoscopic staging, the right colon is mobilized and rotated medially to expose the root of the mesentery. A flexible liver retractor is used to retract segment 4 cranially. An extended Kocher maneuver is performed to release the proximal jejunum from the ligament of Treitz. The jejunum is transected with a 3.5-mm linear cutting stapler 10 cm distal to the former ligament of Treitz and marked with an Endo Stitch 50–60 cm downstream to mark the intended location of the duodenojejunostomy.

## Step 2: Division of the Gastrocolic Omentum, Proximal Duodenum, and Jejunum

The gastrocolic omentum is divided with LigaSure. The groove between the gastroepiploic vascular pedicle and the duodenum is opened

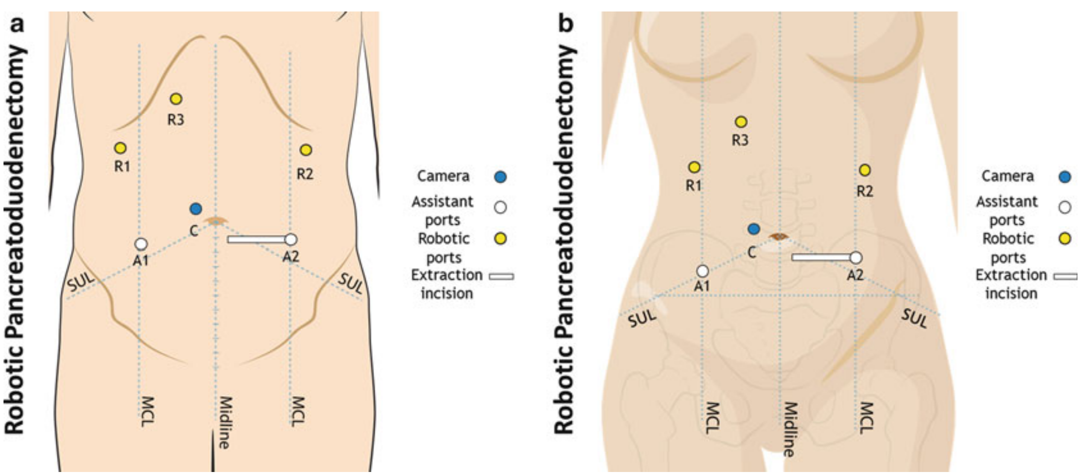


**Fig. 13.1** Position of the ports during a robotic-assisted pancreatoduodenectomy in male (**a**) and female (**b**). The camera port (C) is placed to the right of the umbilicus. Robotic ports (R1, R2, R3) are placed along the subcostal margin as shown. Assistant ports (A1, A2) are placed at the midclavicular line slightly inferior to the umbilicus and the extraction incision as an extension of A2 medially

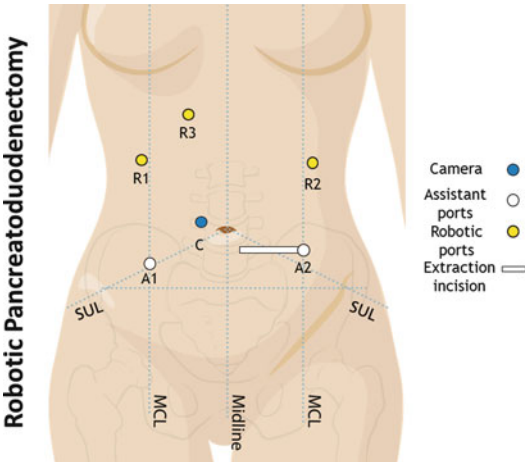


**Fig. 13.2** Room setup. The patient is positioned supine on a split-leg table, and the robot is docked from straight over the patient's head. The robotic surgeon operates the console while the laparoscopic surgeon sits between the patient's legs. A *triangle* of safety is created between the robotic surgeon, the laparoscopic surgeon, and the scrub nurse, ensuring direct visualization among them

with the LigaSure. The right gastric artery is mobilized from the hepatic artery and divided to free the proximal duodenum. The duodenum is divided with a linear cutting stapler, after which the gastroepiploic pedicle is divided with a vascular stapler.

## Step 3: Docking the Robot

The robot is brought over the patient's head with arms 2 and 3 on the patient's right and the patient positioned right side up in steep reverse Trendelenburg (Fig. 13.2). The robotic surgeon operates the console while the laparoscopic surgeon sits between the patient's legs.

## Step 4: Portal Dissection and Division of the Bile Duct

The common hepatic artery (CHA) lymph node is resected and retrieved. The CHA is followed into the porta hepatis. The gastroduodenal artery (GDA) is temporarily occluded to confirm continued flow within the CHA and then ligated and divided with a vascular stapler. The PV is exposed and dissected into the hepatic hilum. The portal lymph nodes are swept into the specimen, searching for an aberrant right hepatic artery. The bile duct is divided with a stapler whenever possible to minimize contamination of the peritoneum with bile. The distal bile margin is resected and sent to pathology.

## Step 5: Mobilization of the Portal Vein and Division of the Pancreatic Neck

The origin of the right gastroepiploic vein is identified as it enters the SMV and divided. The SMV is dissected free from the pancreatic neck, and an articulated laparoscopic grasper is used to pass an umbilical tape beneath the pancreas. 2-0 silk sutures are placed to occlude the transverse pancreatic arteries at the inferior and superior borders of the pancreas. The gland is divided with cautery scissors in an attempt to identify and sharply transect the pancreatic duct.

## Step 6: Division of the Retroperitoneal Margin

The pancreas is elevated from the retroperitoneum using the third robotic arm. Venous tributaries on the lateral margin of the SMV-PV, superior pancreaticoduodenal vein, and tributaries from the first jejunal vein to the uncinate process are ligated with 3-0 silk ties and divided sharply. Arterial branches from the SMA are either divided with the LigaSure or controlled proximally with a silk tie and clip and transected distally with the LigaSure. The specimen is retrieved in a specimen bag and examined by frozen section. Gold fiducials are placed in cases of suspected malignancy. Lastly, antegrade cholecystectomy is performed.

## Step 7: Reconstruction

A duct-to-mucosa pancreaticojejunostomy is performed using a modified Blumgart technique. Interrupted 5-0 Vicryl sutures are placed around the pancreatic duct to facilitate visualization. 2-0

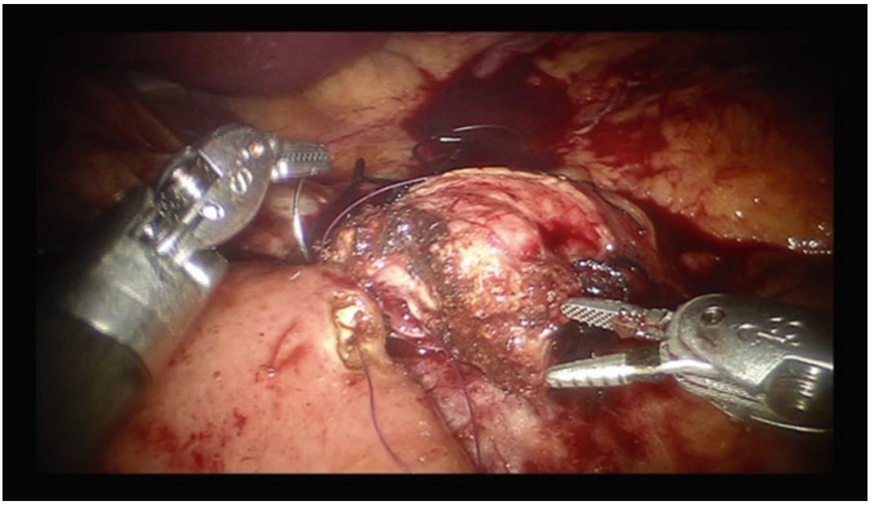

**Fig. 13.3** Pancreaticojejunostomy. Picture demonstrates the corner stitch of the duct-to-mucosa anastomosis performed using a modified Blumgart technique with interrupted 5-0 Vicryl sutures and 2-0 silk horizontal mattress sutures to anchor the seromuscular layer of the jejunum

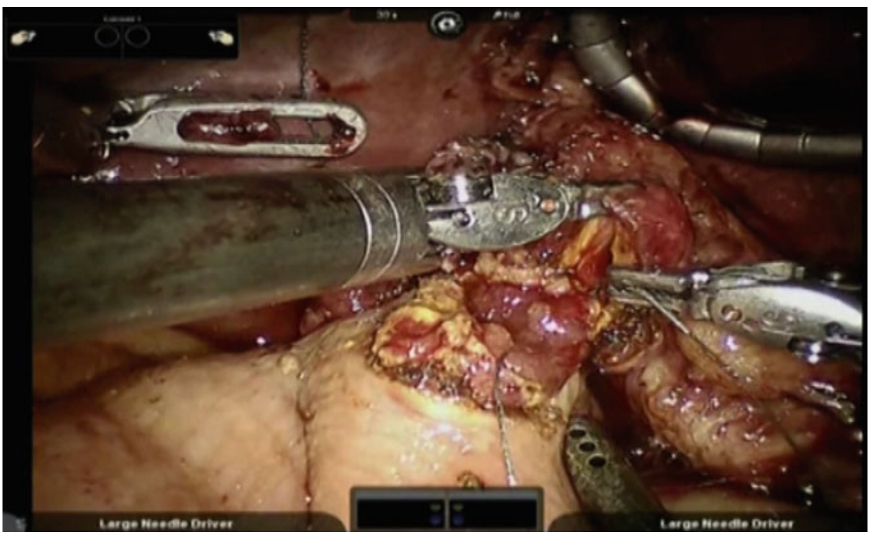


**Fig. 13.4** Hepaticojejunostomy. Picture demonstrates the back row of the single-layer end-to-side anastomosis created with interrupted 5-0 Vicryl

silk horizontal mattress sutures are passed through the pancreas to anchor the seromuscular layer of the jejunum. A small enterotomy is made in the jejunum with robotic scissors, and an interrupted duct-to-mucosa anastomosis is completed (Fig. 13.3). The anastomosis is completed with an anterior layer of 2-0 silk sutures. A single-layer end-to-side hepaticojejunostomy is created with interrupted 5-0 Vicryl (Fig. 13.4). A running technique is used for ducts >5 mm in diameter when visualization is optimal. Finally, an antecolic, two-layer duodenojejunostomy is performed (Fig. 13.5). A posterior layer of interrupted seromuscular 2-0 silk sutures is placed,

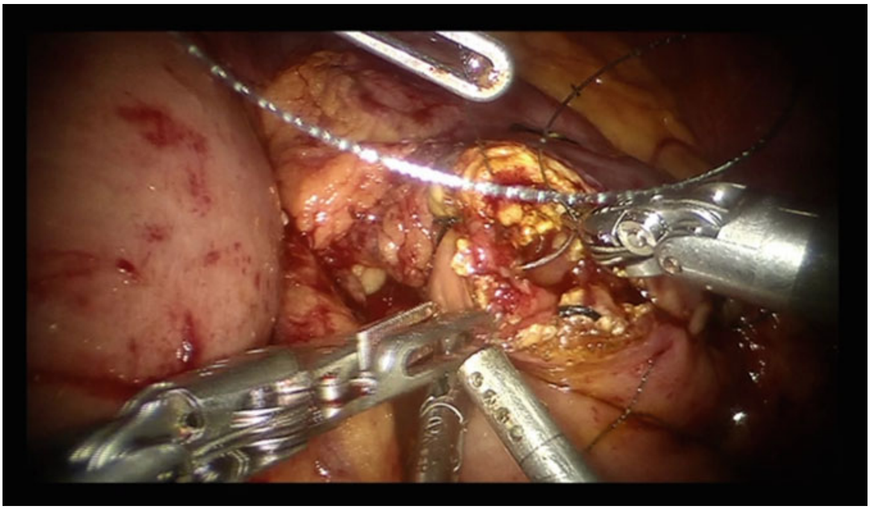

**Fig. 13.5** Duodenojejunostomy. Picture demonstrates the anterior corner stitch of the antecolic, two-layer anastomosis, with interrupted seromuscular 2-0 silk sutures posteriorly, followed by a full-thickness running 3-0 Vicryl after the duodenum and jejunum are opened

followed by full-thickness running 3-0 Vicryl after the duodenum and jejunum are opened. Two round 19 F surgical drains are placed: one anterior and one posterior to the biliary and pancreatic anastomoses. The robot is undocked, and the right lower quadrant incision and camera port are closed. The skin is closed with a monofilament subcuticular closure.

## Outcomes

Analysis of outcomes in our first 50 patients undergoing attempted RAPD demonstrated a median age of 72 years (range 27–85). The predominant indications for surgery were pancreatic ductal carcinoma (14, 28 %), neuroendocrine tumor (10, 20 %), ampullary adenocarcinoma (9, 18 %), and intraductal papillary mucinous neoplasm (9, 18 %). The median duration of attempted RAPD was 568 min (IQR 536–629) including the time to undock and convert to an open procedure in eight patients (16 %). Median blood loss was 350 mL (IQR 150–625), and 11 patients (22 %) required transfusion during their index hospital stay. Conversion to open procedure was required in eight patients (16 %), and the reasons for conversion were failure to progress ($n=4$), unsuspected abutment of the PV by tumor ($n=2$), and unsuspected microscopic tumor at the pancreatic neck margin ($n=2$) by frozen section. At intention-to-treat analysis, pancreatic fistula as defined by the International Study Group of Pancreatic Surgery occurred in ten patients (20 %). The margin-negative resection rate was 89 %, and the median number of lymph nodes collected was 18 [12, 14, 15].

## Conclusion

Robotic-assisted pancreatoduodenectomy (RAPD) allows the recreation of time-tested techniques for open pancreatic surgery through a minimally invasive approach. The robotic platform is able to overcome the current limitations of laparoscopic surgery, including limited range of motion, poor surgeon ergonomics, and lack of 3D view. Early outcomes of robotic-assisted major pancreatic resection are comparable to laparoscopic and open approaches. Technological innovations and increased surgeon familiarity with this approach will lead to greater adoption and acceptance. Next-generation robots may expedite these efforts, hopefully at lower cost.

## References


1. Whipple AO. Pancreaticoduodenectomy for Islet carcinoma: a five-year follow-up. Ann Surg. 1945;121(6):847–52.
2. Traverso LW, Longmire Jr WP. Preservation of the pylorus in pancreaticoduodenectomy. Surg Gynecol Obstet. 1978;146(6):959–62.
3. Howard JM. Pancreatico-duodenectomy: forty-one consecutive Whipple resections without an operative mortality. Ann Surg. 1968;168(4):629–40.
4. Crist DW, Sitzmann JV, Cameron JL. Improved hospital morbidity, mortality, and survival after the Whipple procedure. Ann Surg. 1987;206(3):358–65.
5. Gagner M, Pomp A. Laparoscopic pylorus-preserving pancreatoduodenectomy. Surg Endosc. 1994;8(5):408–10.
6. Palanivelu C, Rajan PS, Rangarajan M, Vaithiswaran V, Senthilnathan P, Parthasarathi R, Praveen RP. Evolution in techniques of laparoscopic pancreaticoduodenectomy: a decade long experience from a tertiary center. J Hepatobiliary Pancreat Surg. 2009;16(6):731–40.
7. Kendrick ML, Cusati D. Total laparoscopic pancreaticoduodenectomy: feasibility and outcome in an early experience. Arch Surg. 2010;145(1):19–23.
8. Gagner M, Palermo M. Laparoscopic Whipple procedure: review of the literature. J Hepatobiliary Pancreat Surg. 2009;16(6):726–30.
9. Giulianotti PC, Sbrana F, Bianco FM, Elli EF, Shah G, Addeo P, Caravaglios G, Coratti A. Robot-assisted laparoscopic pancreatic surgery: single- surgeon experience. Surg Endosc. 2010;24(7):1646–57.
10. Narula VK, Mikami DJ, Melvin WS. Robotic and laparoscopic pancreaticoduodenectomy: a hybrid approach. Pancreas. 2010;39(2):160–4.
11. Moser AJ, Zeh HJ. Robotic pancreaticoduodenectomy. In: Fischer JE, Jones DB, Pomposelli FB, Upchurch Jr GR, editors. Fischer's mastery of surgery, vol. 133A. 6th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2011. p. 92–9.
12. Zureikat AH, Nguyen KT, Bartlett DL, Zeh HJ, Moser AJ. Robotic-assisted major pancreatic resection and reconstruction. Arch Surg. 2011;146(3):256–61.
13. Nguyen KT, Zureikat AH, Chalikonda S, Bartlett DL, Moser AJ, Zeh HJ. Technical aspects of robotic-assisted pancreaticoduodenectomy (RAPD). J Gastrointest Surg. 2011;15(5):870–5.
14. Zeh III HJ, Bartlett DL, Moser AJ. Robotic-assisted major pancreatic resection. Adv Surg. 2011;45:323–40.
15. Zeh HJ, Zureikat AH, Secrest A, Dauoudi M, Bartlett D, Moser AJ. Outcomes after robot-assisted pancreaticoduodenectomy for periampullary lesions. Ann Surg Oncol. 2012;19(3):864–70.
16. Bao P, Potter D, Eisenberg DP, Lenzner D, Zeh HJ, Lee Iii KK, Hughes SJ, Sanders MK, Young JL, Moser AJ. Validation of a prediction rule to maximize curative (R0) resection of early-stage pancreatic adenocarcinoma. HPB (Oxford). 2009;11(7):606–11.