Robotic pancreaticoduodenectomy

Richard Sola Jr[1], Russell C. Kirks[1], David A. Iannitti[2], Dionisios Vrochides[2], John B. Martinie[2]

[1]Department of General Surgery, Carolinas Medical Center, Charlotte, NC, USA; [2]Division of Hepato-Pancreato-Biliary Surgery, Department of General Surgery, Carolinas Medical Center, Charlotte, NC, USA

Correspondence to: John B. Martinie, MD, FACS. Division of Hepato-Pancreato-Biliary Surgery, Department of General Surgery, Carolinas Medical Center, 1025 Morehead Medical Drive, Suite 600, Charlotte, NC 28204, USA. Email: john.martinie@carolinashealthcare.org.

Abstract: Pancreaticoduodenectomy (PD) is considered one of the most complex and technically challenging abdominal surgeries performed by general surgeons. With increasing use of minimally invasive surgery, this operation continues to be performed most commonly in an open fashion. Open PD (OPD) is characterized by high morbidity and mortality rates in published series. Since the early 2000s, use of robotics for PD has slowly evolved. For appropriately selected patients, robotic PD (RPD) has been shown to have less intraoperative blood loss, decreased morbidity and mortality, shorter hospital length of stay, and similar oncological outcomes compared with OPD. At our high-volume center, we have found lower complication rates for RPD along with no difference in total cost when compared with OPD. With demonstrated non-inferior oncologic outcomes for RPD, the potential exists that RPD may be the future standard in surgical management for pancreatic disease. We present a case of a patient with a pancreatic head mass and describe our institution's surgical technique for RPD.

Keywords: Pancreas; pancreaticoduodenectomy (PD); robotic surgery

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Introduction

Pancreaticoduodenectomy (PD) continues to be one of the most complex and challenging abdominal surgeries. The vast majority of PD are still performed as an open operation in the United States (1). Unfortunately, PD has been found to have a perioperative morbidity of 40% and mortality of 5% (2-4).

In 1994, Gagner and Pomp performed the first laparoscopic PD; since that time, the use of minimally invasive surgery for PD has continued to evolve (5,6). Giulianotti *et al*. (7) published the first robotic pancreatic resection in Europe in 2003; in the same year, Melvin *et al*. (8) described the first series of robotic pancreatic resection for neuroendocrine tumor in the United States. Since that time, studies have demonstrated that robotic PD (RPD) can be performed safely with low conversion rates, decreased morbidity and mortality, and a shorter hospital length of stay compared with open PD (OPD) (9-11). Other studies have also demonstrated that RPD has non-inferior oncologic outcomes compared to OPD (12-14). It should be mentioned that none of these papers represented randomized controlled studies but rather very selected individual institution case series. A recent systematic review found an open conversion rate of less than 10% for RPD and morbidity and mortality lower than those found in previous reports for OPD (15).

A review of the experience with RPD at our own institution revealed that, in selected patients, RPD resulted in less blood loss, a shorter intensive care unit (ICU) length of stay, a lower 30-day complication rate, and no difference in total cost compared with OPD even after implementation of an enhanced recovery after surgery (ERAS) pathway (16,17). Perhaps most importantly, we found that, with increasing experience, the pancreatic fistula rate could be reduced to below that of most open series, and certainly lower than most of the series for laparoscopic PD.

Patient selection and workup

A 56-year-old man presented with abdominal pain, jaundice, and acute pancreatitis. Computerized tomography (CT) and magnetic resonance imaging (MRI) identified pancreatitis with pancreatic duct and biliary ductal strictures. No obvious mass was detected; rather, a subtle area of hyperenhancement was detected in the head of the pancreas. The patient underwent endoscopic retrograde cholangiopancreatography (ERCP), which identified common bile duct (CBD) and pancreatic duct strictures, and a biliary endostent was placed. Endoscopic ultrasound (EUS) was subsequently performed and identified a pancreatic head mass. The patient's case was presented at multidisciplinary conference, and consensus among physicians was to proceed with PD. Given no vessel involvement, dilated pancreatic duct, and ideal body habitus, our recommendation was to perform RPD.

Equipment preference card

All robotic cases are performed using the da Vinci Si® robot (Intuitive Surgical, Sunnyvale, CA, USA). Robotic instruments used for RPD include monopolar curved scissors, fenestrated bipolar forceps, a vessel sealer device, and prograsp forceps. The large needle driver is commonly used for suturing as well as dissecting around blood vessels such as the gastroduodenal artery. A Hem-o-lok® Ligation System (Teleflex, Morrisville, NC, USA) is used to control vasculature. Robotic or laparoscopic staplers are used for transection of bowel. Monocryl® and V-Loc™ sutures (Medtronic, Minneapolis, MN, USA) are used for all anastomoses. A LapSac® Surgical Tissue Pouch (Cook Medical, Bloomington, IN, USA) is used for extraction of the specimen.

Procedure

The patient is placed under general anesthesia, and an arterial line and two peripheral intravenous lines are placed. We no longer routinely place central lines. A nasogastric tube and urinary catheter are placed along with sequential compression devices on the patient's lower extremities. The right arm is tucked and the left arm is extended out on an arm board for anesthesia access. The patient is positioned supine with his legs together (not in French position) and the bed is turned 90 degrees so that the left arm is extended towards the anesthesiology team. Only slight reverse Trendelenburg position is utilized.

Pneumoperitoneum is obtained with a Veress needle at the umbilicus and subsequently upsized to an initial 12-mm port. Three additional robotic 8-mm cannulas (right mid-axillary line, left midclavicular line, and left mid-axillary line) and one additional 12-mm camera port is placed in the right mid-clavicular line under direct vision. The umbilical trocar site typically serves as the assistant port during most of the resection portion of the procedure. Most cases require a total of five ports. Upon initial entry, the abdominal cavity is inspected for evidence of metastatic disease, and the round ligament is taken down and preserved for a vascularized pedicle flap as per routine institutional practice. The gallbladder is commonly sutured to the anterior abdominal wall to expose the porta hepatis without the need for a Nathanson retractor, which is used in patients with previous cholecystectomy. The inferior border of the distal gastric antrum and proximal duodenum is mobilized with care. The right gastric and right gastroepiploic vessels are dissected, sealed, and divided using the robotic bipolar vessel sealer device. The proximal duodenum is divided distal to the pylorus using a robotic or laparoscopic stapler device, and the stomach is placed into the left upper quadrant for subsequent reconstruction. The hepatic flexure of the colon is taken down to expose the duodenum, again using the robotic vessel sealer device, and the larger the colon/omentum, the more mobilization is performed. A Kocher maneuver is performed and an attempt is made to mobilize as much of the third and fourth portions of the duodenum from the right side as possible. In a patient with relatively little intra-abdominal fat, the duodenum and ligament of Treitz often can be completely mobilized from the right side. In other patients, the ligament of Treitz must be identified from below the transverse colon or by creating a window in the transverse colon mesentery. The small bowel is transected approximately 20 cm distal to the ligament of Treitz. The small bowel mesentery is divided using the robotic vessel sealer device, staying close to the jejunum towards the root of the small bowel mesentery; the jejunum is then passed through the mesenteric tunnel. It is critical for the surgeon to be capable of performing this difficult maneuver with all three techniques.

Attention is then turned to the portal dissection, where intraoperative ultrasound is always performed to identify and confirm the vascular anatomy and the proximity of the tumor to these structures. Typically, the monopolar scissors are used for this portion of the dissection, which begins with the common hepatic artery lymph node, the medial portal lymph node package, and other nodes extending to the celiac axis. These nodes are all removed and pathologically examined as separate specimens. The gastroduodenal artery is then identified and dissected carefully, ligated with 3–0 silk ties, clipped with Hem-o-lok clips, and divided. A short stump of the gastroduodenal artery should be left on the hepatic artery to prevent the tie or clip from falling off. The inferior border and the neck of the pancreas are dissected out and mobilized, usually by identifying the superior mesenteric vein (SMV) by ultrasound or by following the middle colic vein cephalad. A tunnel is created underneath the neck of the pancreas, on top of the superior mesenteric and portal vein, to the superior aspect of the pancreas. An umbilical tape is passed underneath the pancreas for traction. Finally, the neck of the pancreas is transected using the monopolar scissors coupled with saline irrigation to minimize charring of the tissue, a technique that has been previously described (18). Once within the central portion of the gland, cutting current is also utilized to minimize thermal coagulation of the pancreatic duct.

The uncinate process is mobilized away from the SMV and the superior mesenteric artery (SMA). This must be performed with infinite precision and caution, and with complete understanding of where the SMA and branches are located. To begin, venous branches entering the uncinate coming off of a first jejunal branch of the SMV must be ligated with silk ties, rather than by energy (vessel sealer) or clips to prevent dislodgement later in the reconstruction. Ultrasound is again utilized at this point to visualize the SMA. The robotic vessel sealer is then used to take the uncinate process as close to the SMA as safely possible, but any dominant arterial branch encountered in this portion of the dissection, such as the inferior pancreaticoduodenal artery, is clipped or suture ligated. As the dissection emerges from the superior aspect of the uncinate process, posterior duodenal and portal lymph nodes typically are mobilized and included with the specimen. If not done previously, the proximal gallbladder/cystic duct dissection is performed, and these structures are clipped and divided. The gallbladder remains suspended to the anterior abdominal wall using the previously placed suture for retraction and is removed after the hepaticojejunostomy reconstruction. The common hepatic duct is transected using the monopolar scissors, although occasionally it is either clipped and divided or stapled. The entire specimen is placed into a specimen retrieval bag, removed from the abdominal cavity from the slightly enlarged umbilical trocar site, and sent to pathology for any frozen section margin analysis that may be indicated. For low-grade pathology where margin status is not of concern, the specimen is removed following reconstruction. The specimen retrieval site is partially closed using interrupted sutures around the 12-mm trocar, and the camera is moved to this location for the reconstruction phase of the procedure.

For reconstruction, the stapled end of the jejunum is brought alongside the transected surface of the pancreas, typically through a window made in the right side of the transverse colonic mesentery. A two-layer, end-to-side pancreaticojejunostomy is performed, nearly identical to our open technique. The posterior layer is performed using 5–0 monofilament suture in a running fashion to approximate the capsule of the pancreas with a seromuscular jejunal layer. A small enterotomy matching the diameter of the pancreatic duct is created in the jejunum, and a duct-to-mucosal anastomosis is created using interrupted 6–0 monofilament sutures, typically over a 7- or 5-French pancreatic duct stent. The anterior layer is completed using an additional 5–0 running monofilament suture. The entire anastomosis is wrapped using the round ligament pedicle flap. The hepaticojejunostomy is performed approximately 10–15 cm downstream from the pancreaticojejunostomy using a 5–0 monofilament suture in a running or interrupted fashion depending on the size of the duct. Small, non-dilated ducts must be anastomosed with absolute precision using interrupted monofilament sutures. Finally, an antecolic duodenojejunostomy is performed approximately 50 cm from the biliary anastomosis using absorbable monofilament suture in a running fashion. Occasionally, when the transverse colon and omentum prohibit such a reconstruction due to their bulk, a loop of jejunum is brought up through a mesenteric window made to the left of the middle colic vessels. A single closed suction drain is placed in the right upper quadrant close to the biliary and the pancreatic anastomosis. All port sites are closed appropriately.

Postoperative management

Historically, our patients have had epidural catheters placed by the anesthesiology service. We no longer routinely utilize these catheters; however, in the event the case is converted to OPD, a transversus abdominis plane (TAP) block is performed. Postoperative management includes standardized ERAS protocols for pancreatic surgery.

Figure 1 Clinical presentation and imaging of 56-year-old male with pancreatic head mass. Surgical technique of a robotic pancreaticoduodenectomy (PD) is provided in this video (19). Available online: http://www.asvide.com/articles/1051

Patients are typically discharged on postoperative day 7.

Tips, tricks, and pitfalls

- Avoid the use of epidural catheters;
- If conversion from robotic to open occurs, consider a TAP block;
- Positioning tips: turn bed 90 degrees to allow anesthesia access to extended left arm. Use only slight reverse Trendelenburg;
- Robotic cart should be positioned over patient's head, not over right shoulder;
- Take down round ligament for use as a pedicle flap for pancreaticojejunostomy (minute 1 on *Figure 1*);
- Suture gallbladder to anterior abdominal wall to avoid use of a Nathanson retractor (minute 1 on *Figure 1*);
- Always use intraoperative ultrasound to identify vascular anatomy, especially to distinguish between the middle colic vein and SMV (minute 2 on *Figure* 1);
- Couple saline irrigation during pancreatic transection to minimize charring of the tissue. Use cutting current to minimize thermal coagulation to pancreatic duct (minute 4 on *Figure 1*);
- Use a 7- or 5-French pancreatic duct stent during pancreaticojejunostomy anastomosis (minute 7 on *Figure 1*);
- If the size of the transverse colon and omentum prohibit an antecolic duodenojejunostomy a loop of jejunum is brought up through a mesenteric window made to the left of the middle colic vessels.

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Footnote

Conflicts of Interest: Dr. Martinie serves as a consultant and proctor for Intuitive Surgical. Dr. Iannitti is a consultant and proctor for Medtronic. All other authors have no conflicts of interest to declare.

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