



Robotic central pancreatectomy and pancreatogastrostomy: surgical technique and review of literature

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Contributions: (I) Conception and design: All authors; (II) Administrative support: All authors; (III) Provision of study materials or patients: All authors; (IV) Collection and assembly of data: All authors; (V) Data analysis and interpretation: All authors; (VI) Manuscript writing: All authors; (VII) Final approval of manuscript: All authors.

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Abstract: Improved imaging techniques, coupled with more frequent cross-sectional imaging, have led to a recent rise in the detection of low-grade pancreatic lesions, including intraductal papillary mucinous neoplasms (IPMN), mucinous cystic neoplasms (MCN), pancreatic neuroendocrine tumors (PNET) and solid pseudopapillary tumors (SPEN). Consequently, in addition to more routine procedures to treat resectable pancreatic lesions such as the pancreaticoduodenectomy (PD) and distal pancreatectomy (DP), the use of central pancreatectomy (CP) to resect low-grade, mid-pancreatic tumors has increased. The aim of a CP is the removal of disease while maintaining optimal preservation of the surrounding pancreatic parenchyma. It has been demonstrated that open CP is safe and efficacious, but literature on robotic CP is limited. The aim of this manuscript was to describe the technique of robotic CP and review the current literature. PubMed, Embase and Google Scholar were reviewed to identify literature on robotic CP. Twelve articles reporting 116 patients were identified and data were collected. The overall morbidity and mortality was 64.7%, and 0.0% respectively. Reoperation was required in 1.7% patients, and 56.9%, and 0.9% developed postoperative pancreatic fistula (POPF) and diabetes mellitus (DM) respectively. No postoperative exocrine insufficiency. These outcomes were comparable to those reported for open and laparoscopic CP. Robotic CP is a safe procedure when performed by trained surgeons at high-volume centers.

Keywords: Middle pancreatectomy; central pancreatectomy (CP); robotic surgery; pancreatogastrostomy

Received: 07 November 2017; Accepted: 15 January 2018; Published: 01 February 2018.

doi: 10.21037/apc.2018.01.02

View this article at: <http://dx.doi.org/10.21037/apc.2018.01.02>

Introduction

Ehrhardt reported the first segmental neck resection (SNR) in 1908, followed by Finney in 1910 (1,2). In 1982, Dagradi and Serio performed and reported the first central pancreatectomy (CP) (3-5). Improvements in operative techniques and advancements in surgical instruments resulted in minimally invasive (MIS) approach being utilized to perform various surgical procedures. Baca and Bokan were the first to report laparoscopic CP in 2003, followed by Giulianotti *et al.*, who reported the first robotic CP in 2004 (1,6).

Centrally located pancreatic lesions present a significant challenge, as the surgeon tries to achieve a balance between preserving maximum endocrine and exocrine function of the pancreas while maintaining oncological efficacy (7). There is a variety of options available for surgical resection, including pancreaticoduodenectomy (PD), distal pancreatectomy (DP) or CP. The decision to select a particular approach is dependent upon the size, location and type of pancreatic lesion (3). In cases of main-duct IPMN with an invasive component or transformation to pancreatic ductal adenocarcinoma (PDAC), extended PD or near-total

DP are preferred over CP for complete extirpation of the tumor and its surrounding lymph nodes (7,8). A DP or PD performed for centrally located low-grade lesions would entail the removal of a larger volume of the pancreas. These patients would thus be at a higher risk of post-operative diabetes and exocrine insufficiency without therapeutic benefit (7-9). Small benign lesions can be treated with enucleation, but this procedure is not optimal for malignant tumors or ones next to the main pancreatic duct (10). For patients with centrally located, low-grade malignant or benign disease, CP is a favorable option (10).

Studies have reported that CP can be complicated by the relatively high (20–50%) incidence of post-operative pancreatic fistula (POPF) and incomplete resection of malignant lesions (7). In most cases, however, the POPF is clinically insignificant (9). Additionally, these cases are often in patients with soft glands or small ducts, both being independent, well-established risk factors for POPF (9). Unlike DP, CP allows for splenic preservation, while compared to PD, CP has a lower mortality with duodenal and bile duct preservation (3,7,11). While multiple anastomoses to preserve the functionality of the hepatic and pancreatic ducts and the intestinal tract are necessary in PD, CP requires a single anastomosis for reconstruction (3,11).

MIS is now the standard of care in DP as outcomes are more favorable than in open DP (12,13). A recent meta-analysis demonstrated that laparoscopic DP is associated with less blood loss, shorter hospital length of stay, fewer surgical site infections and lower morbidity compared to open DP (14). The MIS approach to PD has garnered attention for showing comparable morbidity, mortality and oncologic outcomes to open PD in select patient populations (13,15-18). Though both laparoscopic and robotic approaches to CP are being utilized, the smaller operative workspace and complexity of the procedure restrict the utility of laparoscopic CP; robotic surgery can potentially overcome a number of these limitations (10,19-21).

Surgical technique and technical aspects of MIS CP

Appropriate evaluation of patients is performed using a pancreas protocol CT or MRI and serum CA19-9 levels. If the lesion is amenable to resection via robotic CP, an assessment by an anesthesiologist is performed.

The patient is placed in a supine position with both arms extended to 90°. A nasogastric tube, intravenous access, monitoring lines, and Foley catheter are placed.

The abdomen is prepped and draped and is entered using the Hassan technique. The abdomen is then insufflated and a camera port is placed in the periumbilical position. A port is placed in the right anterior axillary line for the liver retractor, followed by two right-sided and two left-sided abdominal robotic ports. Furthermore, an assistant port is placed in the left lower quadrant. The robot is then docked.

Upon entering the abdomen, the abdominal cavity is examined thoroughly. Using a vessel-sealing device, the lesser sac is entered by dissecting the gastrocolic omentum free from the stomach. Of note, the gastroepiploic vessels should be preserved. An ultrasound can be employed to assist in finding the lesion and assess the extent of the tumor invasion and the anatomy of the splenic vessels. The inferior border of the pancreas is mobilized and the superior mesenteric vein (SMV) is identified. The superior border of the pancreas is also mobilized, and the common hepatic artery (CHA), gastroduodenal artery (GDA) and portal vein (PV) are identified. A tunnel is created between the posterior aspect of the neck of the pancreas and the PV. The undersurface of the pancreas is then dissected to free the pancreas from the splenic vessels. The splenic artery can be tortuous and, therefore, meticulous dissection is necessary to avoid vessel injury. As the pancreatic neck is freed from the splenic artery, the overlying coronary vein (left gastric vein) should be identified. It serves as an important anatomic landmark of the celiac trunk, and can be ligated if necessary. Once dissection has been performed to the left of the tumor, a transection plane is identified and marked for pathological examination. The transverse pancreatic arteries are suture ligated, and pancreatic neck is divided using a GIA stapler. The pancreatic parenchyma to the left of the tumor is then transected with cautery scissors or a thermal device while making sure that the pancreatic duct can be identified. The specimen is then placed into an Endo Catch™ (Covidien, New Haven, CT, USA) bag, and removed through the accessory port. Once pathology is confirmed as a benign tumor or a low-grade neoplasm and margins are assessed as being negative, the reconstruction is performed. In case the pathology is found to be malignant or high-grade neoplasm, a formal PD or DP should be performed.

There are two types of reconstruction that can be performed: pancreaticogastrostomy (PG) or Roux-en-y pancreaticojejunostomy. PG is the more commonly used technique. This could be owing to formation of a single anastomosis in comparison to Roux-en-y pancreaticojejunostomy (7). The transected surface of the

pancreas at pancreatic head is oversewn using a running V-Loc™ (Medtronic, Minneapolis, MN, USA) suture to ensure hemostasis.

Subsequently, the stomach is allowed to lie flat in the retroperitoneum and an optimal location for the anastomosis is marked. The mobility of the pancreatic tail is assessed to ensure a tension free anastomosis. The cranial and caudal aspects of the pancreas are anchored to the stomach using Corner sutures. The anterior surface of the pancreas is then sutured to the posterior surface of the stomach to create the 'back row' of the PG. A gastrostomy is created to perform a duct-to-mucosa anastomosis using interrupted 5-0 absorbable monofilament sutures over a pediatric feeding tube as a stent. The posterior surface of the pancreas is then sutured to the stomach in a running manner. In cases where the main pancreatic duct is too small to be visualized, an invagination PG can be performed.

Once the anastomosis is complete, the abdomen is examined to ensure adequate hemostasis. Two drains are placed: one in close proximity to transection surface at the pancreatic head and the other in close proximity to the PG anastomosis. The ports are removed and the skin is closed.

Outcomes of MIS CP

The recent increase in patients undergoing CPs can be attributed to more frequent use of cross-sectional imaging resulting in diagnosis of centrally located low-grade and benign pancreatic lesions (22). Despite an overall increase in the number of CPs performed, MIS-CPs are performed less commonly as compared to open CPs; robotic CP is rarer still compared to laparoscopic CP (23). The study identified and reviewed 12 articles reporting outcomes of robotic-CP (6,10,21,22,24-31). One hundred and sixteen cases were reported and patient demographics and characteristics are detailed in *Table 1*. The overall morbidity was 64.7% (N=75), while 2 (1.7%) patients required reoperation and no mortality was observed. Postoperatively, 66 (56.9%), 1 (0.9%) patients developed POPF, and DM respectively and no patients developed exocrine insufficiency. In a majority of studies, the pancreatic enteric anastomosis was performed via pancreatogastrostomy (10,19,22,23).

The largest series of robotic CP (N=50) was reported by Chen *et al.*, in a randomized control trial that randomized patients between open and robotic CP. They reported a significant reduction in the length of stay (P=0.002), median operative time (P=0.002), and median blood loss (P<0.001) in patients undergoing robotic CP. Furthermore, the rate of

clinically relevant POPF was also reduced in the robotic CP group (P<0.001) (20).

Recently, Ronnekleiv-Kelly *et al.* reported literature available on open CP in which 15 articles reporting 586 patients were identified (3,7-9,11,33-42). Furthermore, they also reported four studies on 17 patients undergoing laparoscopic CP (19,20,43,44). The mean morbidity reported for open and laparoscopic CP was 50.3% (range, 13.0–72.0%) and 35.3% (range, 0.0–44.0%) respectively. The mean morbidity reported for robotic CP in the articles reported in the study was higher than that reported for open and laparoscopic CP: 64.7% (range, 20.0–100.0%). Contrastingly, the mortality reported for open, laparoscopic and robotic CP was 0.7%, 0.0%, and 0.0%, respectively. Reoperation was required in 3.9%, 5.9% and 1.7% of patients undergoing open, laparoscopic and robotic CP. In terms of complications, the rate of POPF was 34.1%, 23.5%, and 56.9% in patients undergoing open, laparoscopic and robotic CP. Interestingly, when Chen *et al.* compared the rate of clinically relevant POPF in the setting of a randomized control trial comparing open and robotic CP, a significant reduction in rates of POPF in the robotic CP group was observed (P<0.001). While the overall rate of POPF in robotic CP remains high, there is a significant reduction in the rates of clinically relevant POPF. The rate of postoperative DM in patients undergoing open, laparoscopic and robotic CP was 3.2%, 0.0%, and 0.9% respectively. Postoperative exocrine insufficiency was only reported in patients undergoing open CP (6.5%). Pancreatogastrostomy was used for pancreatic enteric anastomosis in 66.0%, 37.5%, and 94.9% of open, laparoscopic and robotic CP.

Compared to open CP, there were improved outcomes for mortality, a lower rate of re-operations, and fewer incidences of postoperative endocrine and exocrine dysfunction observed for robotic CP in this review. Outcomes of robotic CP are thus similar to and in some instances more favorable than those observed for open and laparoscopic CP. Despite the relatively limited number of cases available for review, these outcomes suggest that robotic CP is a feasible procedure for certain centrally located pancreatic lesions when performed at high-volume centers by appropriately trained surgeons.

Conclusions

In select patients, robotic CP is a safe and effective procedure when performed by trained surgeons, with

Table 1 Outcomes following robotic central pancreatectomy

Author	Year	N	Morbidity (%)	Mortality (%)	Reoperation (%)	POPF (%)	DM (%)	EI (%)	Recon PG/PJ	OR time, min (mean)	Mean LOS (days)
Giulianotti <i>et al.</i> (6)	2010	3	1 (33.0)	0	0	1 (33.3)	0	0	3/–	320	15
Kang <i>et al.</i> (22)	2011	5	1 (20.0)	0	0	1 (20.0)	0	NR	5/–	360	12
Addeo <i>et al.</i> (24)	2011	1	1 (100.0)	0	0	1 (100.0)	NR	NR	1/–	450	15
Zureikat <i>et al.</i> (31)	2011	4	4 (100.0)	0	0	3 (75.0)	NR	NR	NR	NR	NR
Boggi <i>et al.</i> (26)	2012	3	2 (66.7)	0	0	2 (66.7)	0	0	–/3	390	14
Cheng <i>et al.</i> (28)	2013	7	6 (85.7)	0	0	5 (71.4)	0	0	7/–	150	21
Zhan <i>et al.</i> (29)	2013	10	8 (80.0)	NR	0	7 (70.0)	NR	NR	10/–	219	26
Abood <i>et al.</i> (10)	2013	9	8 (88.9)	0	0	7 (77.8)	0	0	7/2	425	10
Zureikat <i>et al.</i> (21)	2013	13	13 (100.0)	0	1 (7.7)	12 (92.3)	NR	NR	NR	394	8
Zhang <i>et al.</i> (30)	2015	10	8 (80.0)	0	0	5 (50.0)	1 (10.0)	0	10/–	120	20
Addeo <i>et al.</i> (25)	2016	1	0	0	0	0	NR	NR	1/–	290	10
Chen <i>et al.</i> (32)	2017	50	23 (46.0)	0	1 (2.0)	22 (44.0)	NR	NR	50/–	120	16
All studies	–	116	75 (64.7)	0	2 (1.7)	66 (56.9)	1 (0.9)	0	94/5	294	16

OR, operating room; POPF, postoperative pancreatic fistula; DM, diabetes Mellitus; EI, exocrine insufficiency; LOS, length of stay; NR, not recorded.

outcomes comparable to those of the open or laparoscopic approach. It may potentially become an acceptable and even favored approach for these patients given potential benefits of greater preservation of normal pancreatic parenchyma and spleen preservation.

Acknowledgements

None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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doi: 10.21037/apc.2018.01.02

Cite this article as: Javed AA, Hasanain A, Weiss MJ. Robotic central pancreatectomy and pancreaticogastrostomy: surgical technique and review of literature. *Ann Pancreat Cancer* 2018;1:8.