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ORIGINAL ARTICLE

Short-term and pathologic outcomes of robotic versus open pancreatoduodenectomy for periampullary and pancreatic head malignancy: an early experience

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Abstract

Open pancreatoduodenectomy (OPD) is associated with high perioperative morbidity. Adoption of robot-assisted pancreatoduodenectomy (RAPD) has been slow despite ergonomic advantages, improved visualization and dexterity. We aim to report our experience comparing operative and short-term outcomes following RAPD and OPD. We did retrospective analysis of prospectively maintained database, including all consecutive patients who underwent RAPD or OPD between January 2016 and August 2019. 48 patients were included, 21 in RAPD group and 27 in OPD group. RAPD was associated with longer mean operative time (440 vs. 414.1 min) but had significantly less mean intra-operative blood loss (256.9 vs. 404.5 ml), median length of ICU stay (1 vs. 3 days), overall length of stay (11 vs. 13 days) and lower rates of SSI (23.8% vs. 63%). Both groups showed equal incidence of POPF, comparable R0 resection rates (100% vs. 96.3%) and median number of lymph nodes harvested (14 vs. 18). Rate of open conversion was 28.6% ($n=6$), most commonly for bleeding (66.6%) and mesenteric vessel involvement (33.3%). When compared to first ten RAPD cases, mean operative time (483.5 vs. 400.5 min) and rate of conversion (36.36% vs. 20%) was less in last eleven cases. RAPD is significantly better than OPD in terms of intra-operative blood loss, length of ICU stay, length of total stay and SSI. The longer operative time and conversion rate associated with RAPD progressively decreased as experience accumulated and the learning curve was crossed. Further randomized controlled trials are needed to investigate cost-effectiveness and long-term oncologic survival in RAPD patients.

Keywords Pancreatic neoplasm · Robot-assisted pancreatoduodenectomy · Whipple's operation · Robotic surgery · Periampullary carcinoma

Introduction

Minimally invasive surgery has gradually become the standard of care in many abdominal procedures, but adoption of MIS in the field of pancreatic surgery has been relatively slow. Pancreatic resection is technically challenging due to anatomic factors such as the organ's retroperitoneal location and close proximity to the major vasculature. Not surprisingly, open pancreatoduodenectomy (OPD) has a high perioperative morbidity of 30–40% and mortality rate of 1–6% even at the highest volume centers [1].

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Gagner and Pomp described the first laparoscopic pancreatoduodenectomy (LPD) in 1994 [2], Application of laparoscopy to pancreatectomy has been slower than with other abdominal procedures, owing to the requirement of extensive and meticulous dissection in deep and narrow retroperitoneal space and complex digestive reconstructions, making the inherent technical limitations of laparoscopy more evident [3]. Moreover, the long learning curve of LPD has discouraged many surgeons from adopting this technique [4, 5]. However recent literature comparing LPD and OPD have highlighted advantages of LPD including reduced pain, decreased blood loss and need for transfusion, earlier return of bowel function, decreased rates of SSI and shorter ICU and overall length of hospital stay [6, 7].

Robotic approach in PD helps to overcome some of the potential drawbacks associated with laparoscopic procedures applied to the liver and the pancreas, thus potentially enhancing the utilization of minimally invasive surgery in pancreatic surgery [8]. Superiority of robotic assistance has been well-documented for the technically less challenging DP [9, 10]. Although robotic assistance provides better visualization, stable retraction and enhanced surgical dexterity especially in terms of reconstruction, RPD is still not widely accepted in most centers in India. Systematic reviews and meta-analyses in high volume centers have reported the safety and feasibility of RPD [11–15].

As far as we could search, there is a paucity of data involving RPD in India. The aim of our study was to report our early experience comparing operative and short term outcomes following RPD and OPD at a single HPB unit.

Materials and methods

This was a retrospective comparative study spanning three and a half years from January 2016 to August 2019. The study was approved by the institutional ethics committee. Data were obtained from a prospectively maintained database and was analyzed anonymously. We included all patients who underwent successful RPD and OPD for malignant periampullary and pancreatic head tumors at our unit. A total of 48 patients were included in the study, 21 in RPD group and 27 in OPD group. All RPDs were performed by the same surgical team using the da Vinci Si Robotic Surgical System (Intuitive Surgical, Sunnyvale, CA).

Patients were analyzed in an intention-to-treat fashion with all the conversions from robotic to open resection being analyzed in the RPD group. Ethical committee approval was taken prior to the study. A written informed consent was obtained from all the patients enrolled in both groups after explaining the surgical procedure and the study purposes. All patients were informed about the innovative nature of the robotic approach, and evidence emerging from the literature. All clinical cases were discussed at the multidisciplinary hepatobiliary oncologic meeting, during which a consensus for the treatment strategy was reached.

All patients underwent routine blood investigations, contrast enhanced CT scans of the abdomen and pelvis and upper GI endoscopy prior to the surgery. Patients who received prior neoadjuvant therapy also underwent PET CT scanning preoperatively.

Technique of surgery

The patient is placed in supine, 20° reverse Trendelenburg position. Pneumoperitoneum is created using Verre's needle. Abdominal cavity is inspected to rule out potential surgical contraindications (carcinomatosis, metastasis). We use 2 12 mm ports, 3 8 mm ports and a 5 mm assistant port.

Gastrocolic ligament is first divided and lesser sac is accessed. The right gastroepiploic artery and vein are then identified, clipped using Hem-o-lock clips and divided. The confluence of SMV with portal vein is explored behind the neck of the pancreas. This step is done as part of the resectability assessment [16–18]. Hepatic flexure of the colon is mobilized thus exposing the duodenum, SMV and pancreatic head. A wide Kocher manoeuver is performed which allows detachment of head of pancreas from the retroperitoneal space. Landmarks for completion of this step are exposure of left side of the aorta, left renal vein, and origin of the SMA. Enlarged lymph nodes in the interaortocaval space are harvested as part of the lymphadenectomy. This step also aids in assessing tumor resectability (i.e., the SMV/SMA encasement/involvement).

Stomach is divided at the level of third pyloric vein using endoGIA stapler. Hepatic hilar exploration is carried out and right gastric artery is clipped and divided. Gastro duodenal artery is isolated, ligated and divided.

Neck of the pancreas is then transected using da Vinci Harmonic ACE™ Curved Shears (Intuitive Surgical, Inc). Prior to this step polypropylene 2–0 sutures are taken on both edges of the pancreas to aid in retraction as well as to avoid bleeding from the cut edge of pancreas.

Mesocolon is then retracted upwards using the R3 and D4 is mobilized. First jejunal loop is divided using stapler and small jejunal vessels are ligated allowing easier derotation of the duodenojejunal flexure and the detachment of the uncinate process later. The most difficult step of the dissection phase is the uncinate process dissection. This is carried along the right border of superior mesenteric artery in caudocranial direction, while retracting the superior mesenteric vein medially.

After completing dissection along the portal vein, Callots is dissected and Cystic artery is identified and divided, and anterograde cholecystectomy is carried out. CBD is isolated and transected cranial to the origin of cystic duct (Fig. 1).

We begin the reconstructive phase with a single layer, end to side hepaticojejunostomy using continuous 4–0 polydiaxonone suture. Pancreaticojejunostomy is then performed in two layers, with 4–0 polypropylene sutures between pancreatic parenchyma and seromuscular layer of jejunum in continuous fashion and duct to mucosal approximation using 4–0 polydiaxonone sutures in interrupted fashion. 5-7Fr feeding tube is inserted into the pancreatic duct during this step. Gastrojejunostomy is performed using EndoGIA staplers (Figs. 2, 3).

2 Abdominal drains are placed close to the HJ and PJ sites and a closed suction drain is placed in the pelvis. Specimen is extracted using a small upper midline incision.

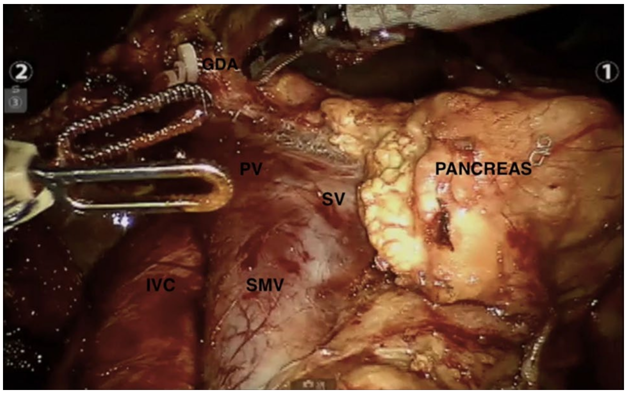

Fig. 1 Portal, splenic and mesentric vessels post completion of dissection. *GDA* gastro-duodenal artery, *IVC* inferior vena cava, *PV* portal vein, *SV* splenic vein, *SMV* superior mesentric vein

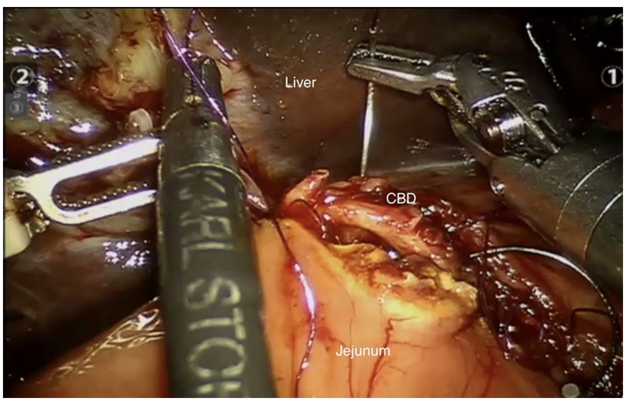

Fig. 2 Hepaticojejunostomy (*CBD* common bile duct)

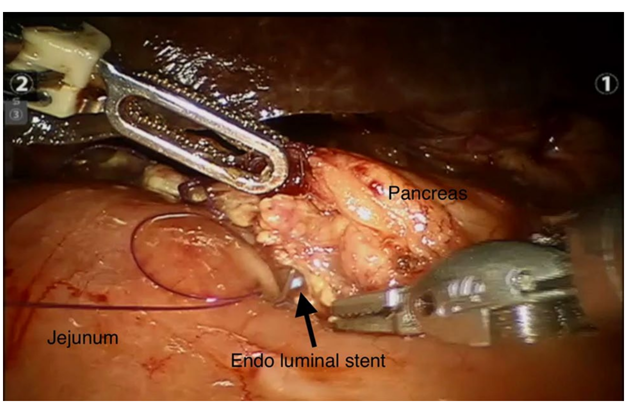

Fig. 3 Pancreaticojejunostomy with placement of Endoluminal stent

Data collection

Data were gathered from our prospectively maintained database. Baseline characteristics included age, gender, body mass index (BMI), Eastern Cooperative Oncology group performance status, American Society of Anesthesiologists grade, and Charlson Comorbidity Index. Tumor-related characteristics included tumor location, histology and clinical staging, according to the eighth edition of the TNM staging for periampullary cancer. Operative characteristics included estimated blood loss and operative time, defined as "skin-to-skin" time. Postoperative stay and ICU stay were recorded. Complications were defined as per International Study Group of Pancreatic Surgery, and stratified as per modified Clavien-Dindo grade.

Bile leakage was defined as bilirubin concentration in the drain fluid at least 3 times the serum bilirubin concentration on or after postoperative day 3, or as the need for radiologic or operative intervention resulting from intra-abdominal biliary collections or peritonitis [19].

Postoperative pancreatic fistula was defined as a drain output of any measurable volume of fluid with an amylase level > 3 times the upper limit of institutional normal serum amylase activity, associated with a clinically relevant condition related directly to the postoperative pancreatic fistula. Pancreatic fistula was classified as biochemical leak, grade B or C according to the updated definition provided by the International Study Group on Pancreatic Fistula (ISGPF) [20].

Postoperative hemorrhage and delayed gastric emptying were defined according to the established international consensus [18].

Pathologic reporting of resected specimens was performed as per College of American Pathologists (CAP) protocol by an experienced oncopathologist. The resection margin was considered negative (R0) when no tumor cells were found within 1 mm from all the assessed margins, or positive (R1) after the confirmation of tumor within 1 mm of each of the six inked margins of resection, as suggested by a standardized protocol [21].

Results

Baseline and preoperative tumor characteristics

Within the duration of the study period, a total of 48 patients meeting the inclusion criteria were identified and included in the study. Of these, 21 patients underwent RPD, whereas, 28 patients underwent OPD. The mean age of patients was 52 ± 12.1 years, with 34 (70.8%) males and 14 (29.2%) females. The mean BMI was 22.1 ± 3.3 kg/m^2. The ECOG performance scale was grade 1 in 14 (29.21%), grade 2 in 32 (66.7%) and grade 3 in two patients (4.2%). The majority of patients belonged to ASA class II (30, 62.5%), followed by class I (16, 33.3%) and class III (2, 4.2%). The two groups were comparable in terms of age, gender, comorbidities and performance status. The baseline and preoperative tumor characteristics of the cohort are summarized in Table 1.

Looking at the preoperative tumor characteristics, tumor location was equally divided between Ampulla (31, 64.6%), Head of Pancreas (9, 18.8%), Distal CBD (4, 8.3%) and Duodenum (4, 8.3%). After PSM, both groups were comparable in terms of tumor characteristics.

Intraoperative outcomes

Intraoperative parameters are depicted in Table 2. Overall the mean operative time was 425.4 ± 57.9 min. The difference in the mean operative time between the two groups was insignificant (440 ± 62.894 min RPD vs. 414.11 ± 52.17 min OPD, $p = 0.135$). Although we observed a remarkable improvement in the mean operative time in RPD group over the course of our experience (First 10 cases – 483.5 ± 44.91 min vs Second 11 cases – 400.5 ± 49.91 min, $p = 0.0007$). The mean estimated blood loss was significantly lower in the RPD group (256.9 ± 28.31 ml RPD vs. 404.52 ± 39.171 ml OPD, $p < 0.0001$).

Six patients in the RPD group had to be converted to open (28.5%). Four of these conversions were owing to bleed from the superior mesenteric vasculature and two of the conversions were due to locally advanced disease. Most of these conversions were in the early stages of our experience.

Post-operative outcomes

Early postoperative outcomes are depicted in Table 2. The median total hospital stay was 12.5 days (IQR 10–14.25 days), and median ICU stay was 2 days (IQR 1–3.25 days). The median total hospital stay and ICU stay in patients undergoing RPD was 11 days (IQR 10–14 days) and 1 day (IQR 1–3 days), respectively, and in patients undergoing OPD was 13 days (IQR 11–15.5 days) and 3 days (2–3.5 days), respectively. There was significant statistical difference in the length of hospital stay ($p = 0.04$) and ICU stay ($p = 0.006$) between the two groups, with RPD group showing lesser hospital and ICU stay.

Pulmonary complications were seen in seven patients (14.6%). More number of patients undergoing OPD had pulmonary complications as compared to RPD but the difference was statistically insignificant. [Five in OPD (18.5%) vs two in RPD (9.5%)]. Two patients developed pulmonary embolism, one in each RPD and OPD group.

It was observed that the incidence of Surgical site infection was significantly lower in the RPD group (23.8% RPD vs. 63% OPD, $p = 0.07$).

Delayed gastric emptying was seen in three patients, one in RPD and in two patients in OPD group. There was no significant statistical difference in incidence of DGE in both groups ($p = 0.71$).

Post-operative pancreatic fistula was seen in 16 patients. Biochemical leak was seen in 13 patients which was managed conservatively. Grade B pancreatic fistula was seen in one patient who underwent Open PD and was managed by somatostatin injections and antibiotic cover. Grade C pancreatic fistula was seen in two patients, one patient in each group, which required re-exploration. The patient in the RPD

Table 1 Baseline characteristics

Variable	Total ($n = 48$)	RPD ($n = 21$)	OPD ($n = 27$)	p value
Age, y (mean ± SD)	52 ± 12.1	52.8 ± 13.24	51.8 ± 11.3	0.785
Sex, n (male%)	34 (70.8%)	17 (81%)	17 (63%)	0.214
BMI, kg/m^2 (mean ± SD)	22.1 ± 3.3	22.86 ± 4.2	21.5 ± 2.2	0.196
ECOG, score n (%)				0.029
1	14 (29.2%)	10 (47.6%)	4 (14.8%)	
2	32 (66.7%)	11 (52.4%)	21 (77.8%)	
3	2 (4.2%)	0 (0.00%)	2 (7.4%)	
ASA, grade n (%)				0.319
I	16 (33.3%)	6 (28.6%)	10 (37%)	
II	30 (62.5%)	15 (71.4%)	15 (55.6%)	
III	2 (4.2%)	0 (0.00%)	2 (7.4%)	
Tumor location n (%)				0.642
Ampulla	31 (64.6%)	14 (66.7%)	17 (63%)	
HOP	9 (18.8%)	5 (23.8%)	4 (14.8%)	
Distal CBD	4 (8.3%)	1 (4.8%)	3 (11.1%)	
Duodenum	4 (8.3%)	1 (4.8%)	3 (11.1%)	

Table 2 Operative analysis

Variable	Total ($n=48$)	RPD ($n=21$)	OPD ($n=27$)	p value
Operating time, min (mean ± SD)	425.4 ± 57.9	440 ± 62.894 (1–10 – 483.5 ± 44.91) (11–21 –400.5 ± 49.91)	414.11 ± 52.17	0.135 0.0007
EBL, ml (mean ± SD)	340 ± 81.6	256.95 ± 28.31	404.52 ± 39.171	< 0.0001
Intraoperative transfusion, n	5	4	1	
Conversion rate, n (%)		6 (28.5%)	–	NS
Total stay, days median (IQR)	12.5 (10–14.25)	11 (10–14)	13 (11–15.5)	0.04
ICU stay, days median (IQR)	2 (1–3.25)	1 (1–3)	3 (2–3.5)	0.006
POPF	16	7	9	1.00
Biochemical leak	13	6	7	0.84
B	1	0	1	0.32
C	2	1	1	0.86
Biliary leakage	0	0	0	–
Delayed gastric emptying, grade C	3	1	2	0.71
Post pancreatectomy hemorrhage	2 (4.2%)	1 (3.7%)	1 (4.8%)	1.00
Pulmonary embolism	2 (4.2%)	1 (3.7%)	1 (4.8%)	1.00
Pulmonary complications	7 (14.6%)	2 (9.5%)	5 (18.5%)	0.445
Surgical site infection	22 (45.8%)	5 (23.8%)	17 (63%)	0.07
Collection	5 (10.4%)	2 (9.5%)	3 (11.1%)	1.00
Re-exploration rate	9 (18.8%)	3 (11.1%)	6 (28.5%)	0.153
Mortality	2 (4.2%)	1 (3.7%)	1 (4.8%)	1.00

group underwent thorough wash and a redo pancreatojejunostomy with feeding jejunostomy. He continued to deteriorate and succumbed to ARDS secondary to septicemia. The patient in the OPD group underwent debridement and wash and recovered postoperatively. He was discharged on POD 26. The difference in incidence of POPF was not statistically significant between RPD and OPD groups ($p=1.00$).

Post pancreatectomy hemorrhage was seen in two patients, one in each group. A total of nine patients (18.8%) required re-exploration. Difference in re-exploration rate between the two groups was observed to be insignificant (11.1% RPD vs. 28.5% OPD, $p=0.153$).

We encountered one mortality in each group. Patient in the RPD group succumbed to ARDS secondary to septicemia following uncontrolled grade C pancreatic fistula and the cause of death in the OPD group was acute pulmonary embolism on post-operative day 2 of the surgery.

Histopathologic outcomes

Table 3 depicts the histopathologic outcomes of this study. The median number of lymph nodes retrieved per case was 14 (IQR 10–20.5). Complete resection was obtained in 47 patients (97.9%). Microscopically positive margins was seen in 1 patient. The number of lymph nodes harvested (14 RPD vs. 18 OPD, $p=0.23$), as well as R0 resection rate (100% RPD vs. 96.3% OPD, $p=1.00$), was comparable in both groups.

Table 3 Histopathological outcomes

Variable	Total ($n=48$)	RPD ($n=21$)	OPD ($n=27$)	p value
Mean lymph node harvested n (range)	14 (10–20.5)	14 (10–20)	18 (10.5–22)	0.23
Margins, n (%)				1.00
R0	47 (97.9%)	21 (100%)	26 (96.3%)	
R1	1 (2.1%)	0	1 (3.7%)	

Discussion

Pancreaticoduodenectomy (PD) or Whipple procedure, remains the mainstay of treatment for peri-ampullary carcinoma and is historically believed to be one of the most difficult abdominal surgical operation as it entails not only extensive dissection around major vessels but also requires formation of complex multiple anastomosis. This classically performed surgery by open technique has high incidence of morbidity and mortality. The high incidence of complications has led to a growing academic interest to improve outcomes through minimally invasive surgical approaches.

Minimally invasive PD was first performed by Gagner and Pomp in 1994 using laparoscopic approach. Recently, Nickel et al. reviewed 224 patients who underwent Laparoscopic and Open Pancreatoduodenectomy. The meta-analysis showed that there was no significant difference regarding LOS, POPF, DGE, PPH, bile leak, reoperation, readmission, or oncologic outcomes between LPD and OPD. Operative times were significantly longer for LPD {MD [95% confidence interval (CI)] 95.44 min (24.06–166.81 min)}, whereas blood loss was lower for LPD [MD (CI) − 150.99 ml (− 168.54 to − 133.44 ml)]. Certainty of evidence was moderate to very low and showed no overall advantage of LPD over OPD [22].

Robotic surgery offers many advantages over laparoscopic surgery in the form of articulation of instruments, binocular enhanced three dimensional vision and elimination of surgeon tremors which allow easy dissection around major vessels and reconstruction of complex anastomosis. Our study represents the first comparative analysis of RPD vs. OPD in India. While this study covers our early experience with RPD, the learning curve was apparent with increasing experience using the robotic platform.

There are several groups who have successfully performed robotic-assisted major pancreatic resections. Giulianotti et al. [23] published first such study which included 60 RPD and demonstrated the safety and feasibility of the procedure. Zeh and Moser [15] demonstrated similar results in their study consisting of 132 Robotic PD patients in 2013, concluding the safety and efficacy of robotic platform as compared to open and laparoscopic techniques.

Various studies comparing Robotic with Open PD showed similar outcomes as our study. Buchs et al. [24] reported that the robotic group had a significantly shorter operative time (444 vs. 559 min; $p = 0.0001$), reduced blood loss (387 vs. 827 ml; $p = 0.0001$), and a higher number of lymph nodes harvested (16.8 vs. 11; $p = 0.02$) compared to the open group. There was no significant difference between the two groups in terms of complication rates, mortality rates, and hospital stay.

Chalikonda et al. [25] reported similar results but with a longer operative time. In his study morbidity occurred in nine patients (30%) following LRPD versus 13 (44%) in the OPD group ($p = 0.14$). Conversion from LRPD to open occurred in three patients (12%) due to bleeding. Reoperation was performed in two patients (6%) following LRPD versus seven (24%) following OPD ($p = 0.17$). Length of hospital stay was 9.79 days for LRPD versus 13.26 days in the OPD group ($p = 0.043$).

A case matched comparison between RPD and OPD was done by Marino et al. [26] which included 35 patients in each arm. EBL, length of stay and overall post-operative morbidity were significantly reduced in the robotic arm.

In our study, there was no statistical difference in the mean operative time between the two groups (440 ± 62.894 min RPD vs. 414.11 ± 52.17 min OPD, $p = 0.135$) which was in contrast to study by Chalikonda et al. but similar to rest of the quoted studies. Although there was a significant improvement in operative time over the course of our experience in robotic group. Similar to outcomes of above mentioned studies, a significant reduction in blood loss was observed in the Robotic group (256.9 ± 28.31 ml RPD vs. 404.52 ± 39.171 ml OPD, $p < 0.0001$). Significant reduction in ICU stay (1 day RPD vs 3 days OPD, $p = 0.006$) and Hospital LOS (11 days RPD vs 13 days OPD, $p = 0.04$) was also seen along with a significant decrease in the incidence of SSI (23.8% RPD vs. 63% OPD, $p = 0.07$) in the robotic group. This in turn helped in reducing the time to initiate adjuvant chemotherapy. There was no significant difference in terms of POPF, bile leak, delayed gastric emptying, PPH and pulmonary complications between the two groups. Lesser number of patients in robotic group required re-exploration but it was not statistically significant (11.1% RPD vs. 28.5% OPD, $p = 0.153$). In terms of oncological outcomes, both groups had a similar lymph node harvest (14 RPD vs. 18 OPD, $p = 0.23$), as well as R0 resection rate (100% RPD vs. 96.3% OPD, $p = 1.00$) [15, 24–27].

We observed that RPD is different from OPD not only in terms of the surgical approach but also in adaptations in technique. (1) We perform the hepatico-jejunal anastomosis prior to pancreaticojejunal anastomosis, following principles of laparoscopic surgery and to avoid tension on the more delicate PJ anastomosis while performing the HJ. (2) It was possible to perform HJ with continuous sutures with 4,0 sutures even in undilated ductal system with the help of enhanced vision, dexterity of instruments and stability of the robotic arms. (3) We also observed a higher rate of duct to mucosal anastomosis in the robotic platform owing to magnified view.

The largest series on RPD was published by Zureikat et al. [27] in 2019 and included 500 consecutive RPDs. Improvements in the post-operative outcomes of last 100 RPDs were noted in terms of Mean operative time, EBL and length of hospital stay. They also highlighted the importance of implementing a structured training program for trainees that involved simulations, drills and operative video reviews prior to embarking on RPD. Integration of trainees into the program did not increase the operative time.

A retrospective multi institutional study comparing RPD with OPD, showed that post learning curve RPD can be performed with similar perioperative outcomes as seen with OPD. No significant difference was noted in major morbidity, however longer operative times were noted in the RPD group [28].

Zhang et al. conducted a systematic review and meta-analysis which revealed that RPD is associated with lower risk of overall complications, re-operations, and positive margin rate. Similarly, a large propensity score matched-analysis published by McMillan et al. concluded that RPD was non-inferior to OPD in terms of clinically relevant POPF incidence and other major postoperative outcomes, including severe complications, hospital stay, and postoperative mortality. However, this study was limited by the fact that 48 surgeons performed OPD in 16 different surgical centers, whereas RPD cases were all from a single institution, leading to a high risk of bias because of the variations in surgical techniques and postoperative management by many surgeons. Despite advances in operative techniques and perioperative management, postoperative mortality and morbidity after PD are reported with an incidence of 5% and 30–40%, respectively, even in many large specialized centers. Clinically relevant POPF is the main contributor to major morbidity and mortality following PD, and this complication is strongly associated with the duration of hospital stay, rates of readmission, and mortality. Thus, any improvement in the postoperative course of such a complex operation cannot occur without a decrease in both incidence and severity of POPF [29].

The limitation of our study is that it is non-randomized and lacks matching. The data used for the study was gathered prospectively, but the nature of the study was retrospective creating selection bias. Further, it lacks assessment of long term outcomes including oncological adequacy, long term survival and QOL.

Conclusion

In our early experience, RAPD was significantly better than OPD in terms of intra-operative blood loss, length of ICU stay, length of total hospital stay and SSI.

The longer operative time and conversion rate associated with RAPD progressively decreased as experience accumulated and the learning curve was crossed. With the dissemination of robotic platform across all fields of surgery, we must now focus on patient safety parameters by minimizing morbidity and mortality and minimize overall cost of the procedure. Adoption of robotics is associated with a high initial capital cost, relatively high annual maintenance liabilities and many single-use instruments. However, with rapidly increasing number of robotic procedures, possible future industry competition and development in technology, it is on the way to become a more cost effective option. Further randomized control trials are required to understand the long term outcomes after RPD in comparison with OPD.

Author contributions All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by JM, NS and AK. The first draft of the manuscript was written by NS and JM and all authors commented on previous versions of manuscript. All authors read and approved the final manuscript. The entire study was conducted under supervision of AK.

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Availability of data and materials The data that support the findings of this study are available with the corresponding author upon reasonable request.

Code availability Not applicable.

Declarations

Conflict of interest The authors have no conflicts of interest to declare that are relevant to the content of this article.

Ethical approval This research study was conducted retrospectively from data obtained for clinical purposes. Ethical Approval was granted by the Narayana Health Academic Ethics Committee of Narayana Health City.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication Not Applicable.

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