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Robotic Distal Pancreatectomy

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ABSTRACT

Background: A robotic-assisted minimal invasive approach has the potential to overcome the limitations of conventional laparoscopic pancreatectomies. We analyzed the outcomes of robotic-assisted distal pancreatectomies (RDPs) to demonstrate the safety and feasibility of robotic distal pancreas resection, including spleen preservation.

Methods: We performed a descriptive retrospective analysis of 40 RDPs. Statistical comparisons were performed between two groups of patients undergoing robotic-assisted spleen-preserving distal pancreatectomy (SPDP) and distal pancreatectomy with splenectomy (SDP). Survival analysis was performed using the Kaplan-Meier method.

Results: Of 49 attempted RDPs, 40 were completed with robotic assistance, with a conversion rate of 18.4%. Compared with the published reports of laparoscopic distal pancreatotomy (DP) and robotic DP, the spleen preservation rate (30%), operating time (203 minutes), major complications rate (5%), fistula rate (20%), and length of hospital stay (5 days) were similar in our RDP patients. Also, the perioperative outcomes of the SPDP and SDP groups did not differ significantly. The median survival was 12.5 months for the patients undergoing RDP for pancreatic ductal adenocarcinoma.

Conclusions: Robotic-assisted distal pancreatectomy, with or without splenic preservation, can be safely performed for lesions of the distal pancreas, with appropriate indications.

Key Words: Robotic-assisted distal pancreatectomy, Laparoscopic distal pancreatectomy, Spleen-preserving distal pancreatectomy, Pancreatic ductal adenocarcinoma.

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INTRODUCTION

The use of minimally invasive approaches for pancreaticobiliary surgery has recently gained wider acceptance. With a well-described favorable safety and outcome profile, the scope of minimally invasive techniques has expanded to include its application in complex pancreatic resections. Distal pancreatectomy (DP) is the method of choice for malignant and benign lesions of the body and tail of the pancreas. Since some early reports in the mid-1990s,[1,2] the laparoscopic approach for DP has been established as a standard surgical technique for this procedure. A review of the literature suggests the safety of laparoscopic distal pancreatectomy (LDP) over open distal pancreatectomy (ODP).[3–7] With the exception of increased operating time, almost all short-term perioperative outcomes have shown favorable trends with the adoption of LDP.[3,4,7]

Despite the excellent benefits of LDP over ODP, the technical difficulties encountered during the complex vascular dissection continue to be the major disadvantage of LDP. Such difficulties become even more pronounced when splenic preservation is attempted during LDP. The advent of robotic technology has supplanted the standard laparoscopic approach, especially in the areas of urologic[8] and gynecologic[9] surgeries. Robotic assistance has been proposed as a solution to overcome the technical disadvantages of conventional LDP.[10] The adoption of a robotic approach could render the complex vascular and tissue dissections amenable to minimally invasive approaches during DP.

Since 2003, a growing number of studies have been published regarding the feasibility of robotic-assisted distal pancreatectomy (RDP).[7,11,12] Although a randomized, prospective study comparing the robotic and conventional LDP is lacking, the available literature supports the safety and feasibility of a robotic approach for DP and splenic preservation during DP. We herein report on a large single-institution series of robotic-assisted DP, with an aim to determine the safety and feasibility of RDP and robotic spleen-preserving DP (R-SPDP).

MATERIALS AND METHODS

We conducted a retrospective chart review of all patients with pancreatic disease who underwent distal pancreatectomy from January 2006 through October 2010. The study was approved by the Institutional Review Board at The Valley Hospital. All RDPs were performed at a single institution by a single surgeon. All patients with surgically resectable distal pancreatic lesions, including patients with chronic pancreatitis, were included in the study. The criteria for exclusions were pancreatic debridement and performance of DP as a part of other abdominal operations. Our data include patients who were converted from robotic to open procedures during DP.

Descriptive data were collected for preoperative variables and included age, gender, race, American Society of Anesthesiologists preoperative class, body mass index, and comorbidities. Intraoperative variables included operating time, rate of conversion from robotic to open procedure, estimated blood loss, rate of splenic preservation, and method of pancreatic stump control. Pathologic data included pathologic diagnosis, greatest diameter of the lesion, length of the resected pancreas, pancreatic resection margin, and locoregional lymph node status. Postoperative complications were graded using the Clavien[13] classification system. Overall morbidity was defined as any postoperative complication that occurred during the hospital admission or during 30 days postdischarge. Postoperative complications above grade II were designated as major morbidities. Pancreatic fistula was defined and graded according to the International Study Group on Pancreatic Fistula (ISGPF)[14] classification. Perioperative mortality was defined as death within 30 days of operation or death during the same admission. Length of hospital stay (LOS) was determined from the date of operation to the date of discharge. Readmission rate was defined as readmission for any indication within 30 days of the date of hospital discharge.

Our technique for RDP begins with the placement of 6 ports (4 robotic trocars including camera port, 5- and 12-mm accessory ports). After placement of the ports and the development of a pneumoperitoneum, the robot was docked into position. After entering into the lesser sac, the superior and inferior borders of pancreas were identified. A retropancreatic tunnel was created, and the splenic vessels were either preserved or divided depending on the need for splenic preservation. The pancreas was mobilized and transected. Depending on the difficulty of the retropancreatic dissection, gland texture, and size, a variety of techniques were used for the transection of the pancreatic body and control of the pancreatic stump.

Continuous variables were expressed as mean ± standard deviation (SD) or median with interquartile range (IQR). Categorical variables were presented as numbers and percentages. The mean values of the continuous variables were compared with either a 2-tailed Student t test or a nonparametric Wilcoxon rank-sum test. Categorical variables were compared using Pearson's χ^2 test or Fisher's exact test contingency tables. The Kaplan-Meier method was used for the calculation of median survival and survival analysis. Logistic regression analysis was performed to predict the risk factors associated with LOS and survival. Statistical significance was defined as a P value $< .05$. The statistical analysis was performed using SPSS version 20.0 (SPSS Inc., IBM, Armonk, New York).

RESULTS

Forty-nine RDPs were attempted during the study period of January 2006 to October 2010. Forty of the 49 attempted DPs (81.6%) were completed with robotic assistance, and 9 were converted to an open procedure, with a robotic-to-open conversion rate of 18.4%.

Patient Demographic Data

The mean age of patients was 70 ± 13.4 years, with an equal gender distribution. Seven of 40 patients (17.5%) were octogenarians (≥80 years). The average number of comorbidities was 2.3, with a median American Society of Anesthesiologists score of 2 (IQR, 2–3). Eight (20%) patients had coronary artery disease, whereas pre-existing diabetes mellitus was present in 11 (27%) patients **(Table 1)**.

Intraoperative Findings

The median operative time was 203 minutes (IQR, 180–235). The median blood loss was 100 mL (IQR, 100–200). Drains were placed routinely in all patients. The pancreas was transected with a stapler in 16 (40%) patients. Electrocautery (n = 22, 55%) was used for pancreatic division when inflammatory changes were encountered, rendering the placement of a stapler across the pancreatic body inaccurate. In addition to the pancreatic transection with the stapler or electrocautery, the pancreatic stump was oversewn in 68% of the patients. Biosealants were used in 8 (20%) patients **(Table 2)**.

Table 1.
Patients' Demographics and Comorbidities

Variable	RDP (n = 40)
Age (y), mean (SD)	70 (13.4)
≥80 y, n (%)	7 (17)
Gender, M/F	20/20
Race, n (%)	
Caucasian	31 (77)
Black	2 (5)
Hispanic	2 (5)
Others	5 (12.5)
Comorbidities, n (%)	
Mean number of comorbidities	2.3
CAD	8 (20)
COPD	2 (5)
DM	11 (27)
ASA score, median (IQR)	2 (2–3)
BMI, mean (SD)	29.4 (5.64)

CAD, coronary artery disease; COPD, chronic obstructive pulmonary disease; DM, diabetes mellitus; ASA, American Society of Anesthesiologists; BMI, body mass index.

Table 2.
Intraoperative Characteristics of RDP

Variable	RDP (n = 40)
Operative time (min), median (IQR)	203 (180–235)
Intraoperative blood loss, mL, median (IQR)	100 (100–200)
Splenic preservation, n (%)	12 (30)
Pancreatic transaction, n (%)	
Staple	16 (40)
Electrocautery	23 (58)
Pancreatic remnant control, n (%)	
Staple only	8 (20)
Staple and suture	8 (20)
Electrocautery and suture	19 (48)
Suture	27 (68)
Biosealant	8 (20)
Pancreatic duct closure with suture	2 (5)

Postoperative Outcomes

The incidence of overall morbidity was 40% (n = 16) in our study. Major complications developed in two (5%) patients; both had postoperative intra-abdominal collections for which image-guided percutaneous drainage was performed. The rate of postoperative pancreatic fistula was 20% (n = 8), of which two (5%) patients developed clinically significant International Study Group on Pancreatic Fistula grade B and/or C pancreatic fistulas. The rates of reoperation and readmission were 5% (n = 2) and 15% (n = 6), respectively. One patient underwent reoperation 30 days after the initial RDP for persistent intra-abdominal abscess. The other patient to undergo reoperation had a serous cystadenoma that was missed during the first RDP and subsequently underwent completion RDP without any complications. There was no perioperative mortality. The median LOS was 5 days (IQR, 4–6). The LOS for 14 (35%) patients was longer than 5 days. The median overall survival for patients with pancreatic adenocarcinoma was 12.5 months **(Table 3)**.

Table 3.
Postoperative Outcomes of Patients Undergoing Robotic Distal Pancreatectomy

Variable	RDP (n = 40)
Overall morbidity, n (%)	16 (40)
Major morbidity, n (%)	2 (5)
Pancreatic fistula, n (%)	8 (20)
Grade A	6 (15)
Grade B	2 (5)
Grade C	0 (0)
Reoperation, n (%)	2 (5)
Readmission, n (%)	6 (15)
Mortality, n (%)	0 (0)
Length of stay (d), median (IQR)	5 (4–6)
Length of stay >5 days, n (%)	14 (35)
Median survival of patients with PDAC (mo)	12.5

Pathology

Fourteen (n = 14, 35%) patients had malignant pathologic findings, whereas 65% (n = 26) of the lesions were benign. The incidence of pancreatic ductal adenocarcinoma (PDAC) was 25% (n = 10). The median tumor size was 3.3 cm (IQR, 2.4–5), and the average length of the resected pancreatic specimen was 7.9 ± 2.8 cm. A median of 4.5 (IQR, 0.75–7.25) lymph nodes were harvested. Four patients (10%) had positive lymph node involvement. Pancreatic margins were positive in 3 (7.5%) patients. Of these 3 patients, only 1 had pancreatic adenocarcinoma and the other 2 had intraductal papillary mucinous neoplasm **(Table 4)**.

Table 4.
Pathology for Patients Undergoing RDP

Variable	RDP (n = 40)
Benign/Low-grade neoplasms, n (%)	26 (65)
Mucinous cystic neoplasm	3
Serous cystadenoma	5
Intraductal papillary mucinous neoplasm	6
Pseudocyst	1
Simple cyst	1
Pancreatic neuroendocrine tumor	8
Other	2
Malignant, n (%)	14 (35)
Pancreatic ductal adenocarcinoma	10 (25)
Intraductal papillary mucinous carcinoma	1
Pancreatic neuroendocrine carcinoma	1
Pancreatic acinar cell carcinoma	1
Renal cell carcinoma	1
Lesion size (cm), median (IQR)	3.3 (2.4–5)
Length of resected pancreas (cm), mean (SD)	7.9 (2.8)
Positive margin, n (%)	3 (7.5)
Number of lymph nodes evaluated, median (IQR)	4.5 (0.75–7.25)
Patients with positive lymph nodes, n (%)	4 (10)

Spleen-Preserving Distal Pancreatectomy

Every attempt was made to preserve the spleen whenever it was not contraindicated. The spleen was preserved in 12 (30%) patients **(Figure 1)**, with a splenic vessel (artery/vein) preservation rate of 92% (n = 11). In one spleen-preserving RDP, the splenic vessels were divided because of extensive retropancreatic inflammatory changes and difficult dissection. The most common reason for splenectomy was preoperative suspicion of pancreatic malignancy (n = 16, 57%). Of 3 attempted splenic preservations using the Warshaw[15] technique, splenectomy had to be performed in 2 patients because, subsequent to ligation of the splenic vessels, the spleen became ischemic. On comparison of the SPDP group with the SDP group, there were no significant differences in intraoperative outcomes, postoperative complications, and median LOS. Three patients who underwent SPDP were later found to harbor a focus of PDAC on postoperative histology, with negative surgical margins. The pancreatic lesions were significantly larger in size in splenectomy patients (4 cm vs 2.4 cm, $P = .003$) **(Table 5)**.

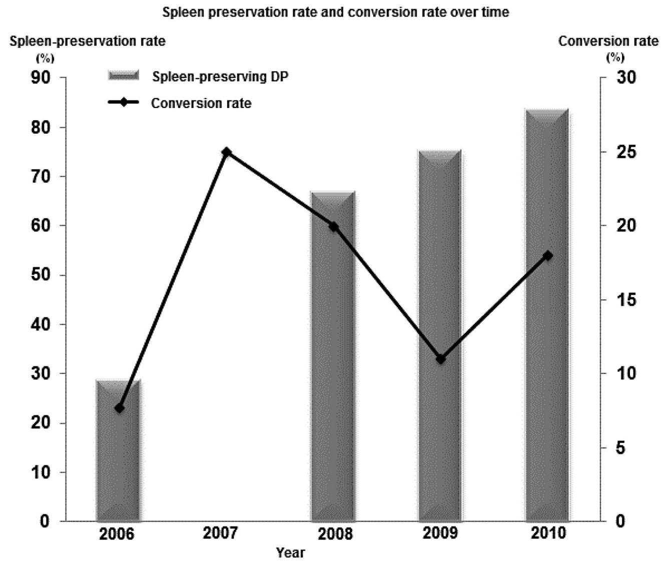

Figure 1. A bar graph of the percentages of successful R-SPDP out of all attempted R-SPDPs demonstrates an increase in the rate of spleen preservation in recent years. A line graph of robotic-to-open DP conversion rates does not show a consistent trend over the same time period.

Robotic-to-Open Conversion

The attempt to perform RDP failed in 9 patients, with a robotic-to-open conversion rate of 18.4% **(Figure 1)**. Tumor involvement of the splenic vessels and difficult vascular dissections were the reasons for conversion in 6 (67%) patients, whereas major intraoperative bleeding led to conversion in the other 3 (33%) patients. Malignancy was present in 7 (77.8%) of the converted to open patients, of which 5 lesions were pancreatic ductal adenocarcinomas. In a separate subset comparison with the RDP group, robotic-to-open converted patients had significantly increased operative time, intraoperative blood loss, incidence of major complications, and median LOS.

DISCUSSION

LDP[3,4,5,11] is being performed more frequently for the resection of lesions of the pancreatic body and tail. A shortened LOS and significant improvement in postoperative outcomes has established LDP as the preferred operation for distal pancreatic resections compared with ODP. By modifying and adapting the critical anatomic steps of open surgery, laparoscopic surgeons have been able to achieve excellent outcomes with distal pancreatic resections. Despite the tremendous advances in the minimally invasive techniques, the traditional laparoscopic approach remains plagued by limitations such as reduced

Table 5.
Perioperative Outcomes for Patients Undergoing RDP: Splenic Preservation vs Splenectomy

Variable	Splenic Preservation (n = 12)	Splenectomy (n = 28)	*P* Value
Intraoperative characteristics			
Operative time, median (IQR)	185 (145–230)	208 (180–237)	.22
Intraoperative blood loss (mL), median (IQR)	150 (88–213)	100 (100–200)	.69
Pathology, n (%)			
Benign/low-grade neoplasms	9 (75)	17 (61)	.48
Malignant	3 (25)	11 (39)	.48
Pancreatic ductal adenocarcinoma	3 (25)	7 (25)	1.00
Lesion size (cm), median (IQR)	2.4 (1.65–3)	4 (2.5–6.35)	.003
Length of resected pancreas (cm), mean (SD)	6.85 (2.93)	8.4 (2.69)	.11
Postoperative outcomes, n (%)			
Overall morbidity	6 (50)	10 (36)	.49
Major morbidity	2 (17)	0 (0)	.09
Pancreatic fistula	2 (17)	6 (21)	.73
Reoperation	0 (0)	2 (7)	.99
Readmission	3 (25)	3 (11)	.34
Mortality	0 (0)	0 (0)	
Length of stay (d), median (IQR)	4.5 (4–6.25)	5 (5–6)	.59

dexterity, 2-D vision, and poor ergonomics. In addition, a lack of consensus exists regarding the universal adoption of a laparoscopic approach for spleen preservation during DP. The tedious instrumentation needed during SPDP for retroperitoneal and, especially, splenic hilar vascular dissections could easily lead to deviations from the principles of ODP. Such technical deviations have the potential to compromise the safety of distal pancreatic resections. With its inherent advantages like enhanced dexterity, 3-D imaging, multiarticulation, and improved ergonomics,[8] robotic assistance during DPs could help surgeons closely mimic the principles of ODP. This would help surgeons attain the excellent outcomes of both the open and minimally invasive approaches, such as a safe and oncologically adequate R0 resection, as well as reduced wound complications and a shorter hospital stay, with an improved perioperative course.

Since the initial reports by Melvin et al[11] in 2003, RDPs have slowly gained acceptance in the surgical community. At The Valley Hospital, we have been performing distal pancreatectomies with robotic assistance since 2001, and currently all minimally invasive distal pancreatic resections are attempted with robotic assistance. Although the technical details of RDP have been reported regularly, there is a lack of outcome studies of RDPs in the published literature. The available limited literature suggests that RDP can be performed safely in a cost-effective manner.[7] In the current retrospective analysis, we have described the largest series of RDPs reported in the United States, to the best of our knowledge. Of interest are two other reports of large series of RDP and their outcomes. In one of these RDP series, Giulianotti et al[12] described the outcome of 46 RDPs performed at two locations (19 in the United States and 29 in Italy). Their robotic-to-open conversion rate was 6.5%, with a postoperative pancreatic fistula rate of 20.9%. The other published series by Waters et al[7] described 17 RDPs and compared RDP with ODP and LDP. The authors were able to achieve a low robotic-to-open conversion rate of 6%, with a reduced amount of blood loss in the RDP group. However, the operative time was higher in the RDP group compared with the ODP group (298 vs 234 minutes) and LDP (298 vs 224 minutes). The conclusion of the study was that RDP is safe based on a comparable morbidity profile with ODP and LDP. Other published reports on RDP are mostly case reports and small case series.[16–19]

In our study, the median operative time for RDP was lower compared with that of Waters et al. The amount of blood loss was also less. Robotic DP has also been found to have a lower conversion rate when compared with LDP

(12.6–25.3%).[3,6,20] Our high robotic-to-open conversion rate of 18.4% compared with the Waters or Giulianotti groups could possibly be a result of the universal application of RDP for all patients, which reflects our attempt to maximize the benefits of minimally invasive surgeries whenever possible. This might also account for the higher positive pancreatic margin rate (7.5%) in our series compared with that of Waters et al, because, unlike the authors in that study, we did not exclude PDAC from the RDP group. Advanced preoperative imaging studies could potentially assist in selecting the best cases suited for the robotic technique. We believe that a surgeon's experience in performing robotic surgeries has the largest impact on conversion rates. There were no robotic-to-open conversions in our recent cases. Also, the median number of harvested lymph nodes was low, and this result was consistent with other RDP studies.[7] We observed a downward trend for the need of hand assistance during the study period, with no hand-assisted RDPs performed in the past 3 years.

Patients performed well clinically after DPs in our series, with no in-hospital or 30-day mortalities. In the literature, the incidences of morbidity and pancreatic fistula have been reported to be 32% to 57%[7,21] and 10% to 50%,[7,22–24] respectively. The incidences of overall morbidity (40%), major complications (5%), and pancreatic fistula (20%) were within the range of the published reports. Our results were also comparable with the RDP series described by Giulianotti et al[12] (pancreatic fistula rate 20.9%), although it was not better than that of Waters et al[7] (morbidity 18%), which again could be caused by the exclusion of pancreatic cancer patients from the RDP group in the Waters study. We were able to realize the benefits of minimally invasive operations because the postoperative outcomes profile and median LOS of 5 days echoed recently published literature about LDP[3,25–27] and RDP.[7,12] The method of pancreatic transection is of vital importance because it has been shown to affect the development of pancreatic fistula.[28] We have found that the technique of using electrocautery with anterior-to-posterior pancreatic resection under complete vision is safe when dense retroperitoneal fibrosis and inflammation are encountered. Regardless of whether a stapler (40%) or electrocautery (58%) is used, in most patients, the transected pancreas was oversewn (68%) with nonabsorbable sutures **(Table 2)**.

The importance of the role of splenic preservation during DP in the maintenance of long-term immunologic and hematologic functions is undisputed.[29–31] At the same time, the role of spleen preservation in reducing short-term perioperative morbidity and infectious complications is still being debated. Studies, including that of Shoup et al[32] at the Memorial Sloan-Kettering Cancer Center, have demonstrated a significant reduction in short-term postoperative morbidities and infectious complications in SPDP patients, whereas others either failed to replicate similar outcomes or have even concluded that spleen preservation leads to increased morbidities.[33,34] Technical difficulties and prolonged operative time[35,36] have been reported to be the major disadvantages of splenic preservation during DPs, especially when the preservation of splenic vessels[29] is also desired. A reduction in postoperative thrombocytosis and a reduced risk of hemorrhage have been cited as potential benefits of vessel-sparing spleen preservation.[37] En bloc division of splenic vessels with the maintenance of the short gastric vessels' integrity[15] is a technically simpler and time-saving method of splenic preservation; however, this technique does potentiate the risk of splenic infarction and subsequent formation of splenic abscess.

In our series, of 24 attempted SPDPs, we were able to preserve the spleen in 12 patients. Our spleen preservation rate of 50% is similar to that of Giulianotti et al[12] (RDP 50%) and Waters et al[7] (RDP 65%, LDP 28%). The rate of splenic vessel-preserving DP (n = 11, 92%) was similar to the published literature about RDP[7] (100%) and was better than that of LDP[7] (18%). Overall, we did not observe any difference in the operative time, blood loss, and clinical outcomes, such as morbidity, the development of pancreatic fistula, and LOS, between SPDP and DP with splenectomy patients.

The oncologic appropriateness of minimally invasive DP for cancerous indications is not well established. By virtue of its commonly late presentation and associated inflammatory process,[4] laparoscopic resection of the malignant lesions with DP carries the inherent risk of achieving unsatisfactory oncologic outcomes.[38,39] In terms of oncology outcomes, published reports vary widely because of a lack of uniformity in regards to the inclusion of PDAC and complex cases in LDP[3] or RDP[7] groups. In our study, the attempt to resect all lesions of the tail of the pancreas by the robotic approach resulted in an expected high conversion rate. We were able to achieve oncologic adequacy as only one PDAC had positive pancreatic margins (n = 1, 7%), which was comparable with the study by Fernandez-Cruz et al,[40] who reported a positive margin of 10% in 13 PDACs by LDP, although it was higher than Waters et al[7] (0% in LDP group). Another large series by Kooby et al[20] achieved a positive margin rate of 26% in LDP and 34% in ODP for PDACs, although they also included the radial margin involvement in their margin reporting. With the inclusion of radial margins, the incidence of positive pancreatic margins for PDAC was 14.3% (n = 2) in our series. Compared with ODP (12.3–14)[7,20] and LDP (6–14.5),[3,7,20,40] a lower number of lymph nodes retrieved during RDP (n = 5)[7] has been described by other investigators, and our results, which report a median number of lymph nodes as 4.5 for all pathologies and 5 for malignancies, were consistent with these findings. Different rates of splenic preservation in these studies could have resulted in such variations because hilar lymph nodes constitute the largest number of lymph nodes. Spleen preservation during DP for carcinomas is oncologically contraindicated, although in 3 of our SPDP patients, when pathology showed PDAC, the surgical margins were not involved. Focal PDAC was present in a background of intraductal papillary mucinous neoplasm and chronic pancreatitis in these patients. In our view, spleen preservation should be universally attempted in benign or low-grade lesions, and intraoperative frozen sectioning could assist in making an informed decision when performing cancer surgery. We conclude that spleen preservation, even with splenic vessel-sparing, can be safely performed during RDP for appropriate oncologic indications excluding PDAC.

Survival analysis showed a median survival of 12.5 months for PDAC patients undergoing RDP. The median survival was close to the survival outcomes from other ODP and LDP series (14–27 months).[20,40–42] In univariate analysis, the number of comorbidities and diagnosis of cancer were the only variables that had individually significant associations with overall survival. They were subsequently entered into a multivariate regression model and remained significantly associated with survival ($P = .01$). A higher number of comorbidities and cancer diagnoses were associated with reduced overall survival in our patients. We did not find any associations between perioperative variables and hospital stay longer than 5 days. Based on our data and other authors' experience, we can safely conclude that robotic assistance during DP does not result in a worse oncologic outcome when compared with ODP.

Although this study is mainly descriptive, the lack of a control LDP or ODP group is a major limitation. Retrospective analysis and a relatively small patient population are other limitations of the present study. In addition, our survival analysis was limited to overall survival, and disease-free survival was not determined. Despite the limited discussion related to the oncologic outcomes of RDP, the study was not designed to determine the long-term oncologic results of RDPs. Our supporting data on splenic preservation are limited to short-term outcomes, whereas a long-term infectious outcome is needed to convincingly demonstrate the advantages of SPDP.

Beyond the statistical and design limitations of our study, a discussion of the limitations of the robotic approach is pertinent. Increased costs associated with the adoption of robotic technology and increased operative time remain major hindrances to the widespread use of robotic surgery. In a cost-effectiveness and outcomes study, Waters et al[7] found a significant increase in the operative cost of RDP compared with laparoscopic and open procedures. Interestingly, the overall cost of hospital stay failed to show any difference among the 3 groups. The authors concluded that the increased operative cost of robotic surgeries could be offset by a reduced length of hospital stay and a reduction in major complication rates. In our study, we did not have enough cost breakdown data to perform a cost-effectiveness analysis. In addition, the lack of laparoscopic or ODP control groups precluded the cost-comparison analysis. We were unable to compare the robotic outcomes with our historic laparoscopic and ODPs because of problems with the medical record system before 2005. We concur with the findings of Waters et al and believe that a larger, prospective, controlled study comparing the 3 surgical approaches would be able to convincingly demonstrate the cost effectiveness of RDP. In addition, a lack of tactile feedback could be a limitation for safe vascular dissection. In our experience, an enhanced visual feedback during robotic surgeries could adequately compensate for this weakness.

A majority of cases can be performed laparoscopically by experienced laparoscopic pancreatic surgeons. Of note, robotic assistance can enable surgeons who do not have advanced laparoscopic training to still perform complex pancreatic surgeries with a minimally invasive technique. The learning curve for robotic-assisted pancreatic surgeries is considered to be high. The time required for learning the setup of a robotic system and instrument maneuvering such as dissection and knot-tying varies among surgeons but is still considerably less than laparoscopy. For an experienced pancreatic surgeon, it should not take long to master the routine robotic pancreatic surgeries such as DP. In our experience, an average of 5 distal pancreatosplenectomies and 10 splenic vessel-preserving DPs should make a surgeon feel comfortable in performing these robotic-assisted pancreatic surgeries. These are not absolute numbers and will vary among surgeons.

CONCLUSION

RDP is a safe and feasible option for selective distal pancreatic lesions. The perioperative outcome profiles are comparable with laparoscopic and ODPs. An increased spleen salvation rate can be achieved in RDP, and technically complex maneuvers like splenic vessel preservation can be performed. Although short-term postoperative outcomes of RDP for PDAC are encouraging, further analysis is needed to determine the oncologic soundness of a robotic approach for pancreatic ductal adenocarcinoma of the distal pancreas. In addition, a randomized controlled study is needed to further demonstrate the efficacy and cost-effectiveness of robotic-assisted distal pancreatic resections compared with open and laparoscopic pancreatectomies.

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