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Surgical Outcomes of Robotic Distal Pancreatectomy Versus Laparoscopic Distal Pancreatectomy at a Hospital in a Sparsely Populated Area

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ABSTRACT

Background Robotic distal pancreatectomy (RDP) has a better or comparable surgical outcome when compared with laparoscopic distal pancreatectomy (LDP). However, whether the surgical outcome for these procedures in local, low-volume hospitals are comparable with those of the typically larger centers described in published reports remains unclear.

Methods This study enrolled 48 patients who underwent either RDP or LDP between August 2012 and April 2023. Data were retrospectively analyzed to evaluate the short-term surgical outcomes of RDP versus LDP in our hospital, which is a low-volume center.

Results The use of stapling with reinforcement in RDP was significantly higher than in LDP, and the postoperative hospital stay for RDP was significantly shorter than for LDP. Except for these two variables, there were no statistically significant differences between RDP and LDP in preoperative, intraoperative, or postoperative patient characteristics.

Conclusion RDP can be performed as safely and effectively as LDP in a low-volume hospital located in a sparsely populated area.

Key words local hospital; low-volume center; robotic distal pancreatectomy

Minimally invasive surgery has become a widely adopted surgical approach in the field of digestive surgery. In hepatobiliary and pancreatic surgeries, for example, distal pancreatectomy (DP), which is performed for tumors located in the pancreatic body and tail, has been considered suitable as a minimally invasive approach. Furthermore, either laparoscopic or robotic surgery can be utilized because reconstruction of the gastrointestinal tract, biliary tract, and pancreas is not required. Several cohort studies reported by high-volume international centers as well as systematic reviews conclude that robotic distal pancreatectomy (RDP) has better or comparable surgical outcomes as laparoscopic distal pancreatectomy (LDP).[1–5] Hence, it is expected that in the future, RDP rather than LDP will be applied for a tumor located in the pancreatic body or tail. However, local hospitals in Japan not only have fewer experienced surgeons with Japanese hepatobiliary–pancreatic (HBP) certification but also perform fewer pancreatectomies compared with urban hospitals. Therefore, whether surgical outcomes in local, low-volume hospitals such as ours are comparable with the published reports of high-volume centers with respect to minimally invasive distal pancreatectomy (MIDP) remains unclear.

This study aimed to compare the short-term surgical outcomes of RDP versus LDP and to evaluate whether surgical outcomes of RDP in a local, low-volume hospital were comparable with those in previous reports.

SUBJECTS AND METHODS

Patients

Between August 2012 and April 2023, MIDP was performed in 49 patients at Tottori University Hospital. This retrospective study included 48 patients who underwent either RDP or LDP; one patient was excluded because the patient underwent DP with a hand-assisted approach. These 48 patients were categorized according to the surgical technique: RDP or LDP. The Tottori University Hospital Ethics Committee approved this study (No. 22A157), and the informed consent requirement was waived.

Pancreatectomy procedures

All MIDP procedures were done by the same experienced hepatobiliary–pancreatic surgeon, and the two surgical assistants were a gastrointestinal surgeon who had less experience with hepatobiliary–pancreatic surgery and a surgical resident. RDPs were performed using the da Vinci Xi robotic surgical system (Intuitive Surgical, Sunnyvale). The pancreatic transection line

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Abbreviations: DP, distal pancreatectomy; HBP, hepatobiliary–pancreatic; LDP, laparoscopic distal pancreatectomy; MIDP, minimally invasive distal pancreatectomy; RDP, robotic distal pancreatectomy

Table 1. Patient characteristics and preoperative variables*

Variable	RDP (n = 17)	LDP (n = 31)	P-value
Age, years, median (range)	68.0 (27–76)	72.0 (19–86)	0.207
Sex (male), n (%)	7 (41.2%)	11 (35.5%)	0.697
Body mass index, kg/m^2, median (range)	23.9 (19.4–26.8)	21.2 (14.9–28.8)	0.134
Histopathological diagnosis, n (%)			0.831
Pancreatic ductal adenocarcinoma	6 (35.3%)	10 (32.3%)	
Other disease	11 (64.7%)	21 (67.7%)	
ASA-PS (1 or 2, %)	15 (88.2%)	24 (77.4%)	0.359
Preoperative albumin, g/dL, median (range)	4.2 (3.7–4.7)	4.4 (3.3–4.9)	0.153
Preoperative lymphocyte count, median (range)	1,504 (840–2,800)	1,400 (714–2,728)	0.804

*Continuous variables are expressed as median with range. ASA-PS, American Society of Anesthesiologists Physical Status (classification); LDP, laparoscopic distal pancreatectomy; RDP, robotic distal pancreatectomy.

was determined by assessing tumor location using preoperative multidetector-row computed tomography in the portal phase. The pancreatic parenchyma was generally divided above the portal vein, while in patients with low-grade malignant or metastatic tumors or benign disease located in the pancreatic tail, the pancreatic parenchymal transection line was shifted to the left edge of the superior mesenteric artery. The pancreatic parenchyma was transected using the Endo GIA black reload with Tri-Staple technology (Covidien Japan, Inc., Tokyo, Japan) with reinforcement using a Neoveil® polyglycolic acid sheet (Gunze Medical Division, Kyoto, Japan) during and after January 2017, and without such reinforcement before January 2017. Pancreatic fistula was defined according to the definition of the International Study Group of Pancreatic Fistula.[6]

Drain removal

Regarding the criteria for removing the drain in our institution: before January 2017, we removed the drain on postoperative day (POD) 3 or 4 if the amylase level in the drainage fluid on POD 3 was less than three times the serum value or less than <800 IU/L as an absolute value, and the drainage fluid was clear. After POD 5, the drain was maintained until the postoperative pancreatic fistula resolved, according to the judgment of the experienced hepatobiliary–pancreatic surgeon in our institution. In contrast, after January 2017, we removed the drain on POD 3 or 4, regardless of the amylase level and drainage fluid volume, if infection were confirmed to be absent according to a bacterial smear test performed on POD 3.

Clinicopathological variables

The clinicopathological variables in this study were collected from patients' medical records as follows: age; sex; body mass index; histopathological diagnosis (pancreatic ductal adenocarcinoma or other disease); preoperative albumin; preoperative lymphocyte count; American Society of Anesthesiologists physical status classification; operative time; estimated blood loss; spleen preservation; conversion to open surgery; thickness of the pancreatic transection line; stapler use with reinforcement; drain amylase levels on POD 1 and 3; serum C-reactive protein levels on POD 1, 3, and 5; duration of drainage; postoperative pancreatic fistula; length of postoperative hospital stay; reoperation within 30 days; readmission within 30 days; and mortality within 90 days after surgery.

Statistical analysis

The continuous variables were expressed as median with range, and categorical variables were expressed as number (proportion, %). To evaluate between-group differences in the clinical variables, the Chi-square test or Fisher's exact test was used for categorical variables, and the Mann–Whitney U-test for continuous variables. $P < 0.05$ was considered statistically significant. All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY).

RESULTS

Of 48 patients, RDP was performed in 17 patients and LDP in 31 patients. Patients' characteristics and preoperative variables are summarized in Table 1. There were no statistically significant differences in patient characteristics between the two groups, including age, sex, body mass index, American Society of Anesthesiologists physical status classification,

Table 2. Comparison of intra-operative variables between RDP and LDP

Variable	RDP (n = 17)	LDP (n = 31)	P value
Spleen preservation, n (%)	2 (11.8%)	5 (16.1%)	1.000
Operative time, min, median (range)			
Spleen-preserved	436 (383–489)	447 (308–499)	1.000
Spleen-removed	437 (273-511)	383 (209-537)	0.127
Convert to open surgery, n (%)	0 (0.0%)	2 (6.5%)	0.533
Thickness of the pancreatic transection line, mm, median (range)	12.6 (6.5–18.7)	11.0 (5.4–17.4)	0.643
Stapler with reinforcement, n (%)			0.004
Present	17 (100%)	19 (61.3%)	
Absent	0 (0.0%)	12 (38.7%)	
Estimated blood loss, ml, median (range)	40 (1–135)	50 (1–975)	0.321

Continuous variables are expressed as median with range. LDP, laparoscopic distal pancreatectomy; RDP, robotic distal pancreatectomy.

Table 3. Comparison of postoperative variables between RDP and LDP*

Variable	RDP (n = 17)	LDP (n = 31)	P-value
Postoperative pancreatic fistula, n (%)			
Biochemical leakage	7 (41.2%)	12 (38.7%)	0.867
Grade B	0 (0.0%)	4 (12.9%)	0.282
Grade C	0 (0.0%)	0 (0.0%)	N/A
Drain amylase level on POD 1, IU/L, median (range)	3,112 (124–19,397)	3,104 (395–15,836)	0.838
Drain amylase level on POD 3†, IU/L median (range)	229 (66–5,589)	416 (39–2,069)	0.991
Serum CRP level on POD 1, mg/dL, median (range)	2.61 (0.92–9.77)	3.44 (0.98–16.31)	0.240
Serum CRP level on POD 3, mg/dL, median (range)	14.38 (5.30–28.3)	15.92 (3.4–26.79)	0.738
Serum CRP level on POD 5, mg/dL, median (range)	5.82 (1.59–15.42)	6.25 (1.05–17.76)	0.612
Duration of drainage, days, median (range)	4 (4–6)	4 (3–125)	0.553
Reoperation within 30 days, n (%)	0 (0.0%)	1 (3.2%)	> 0.999
Readmission within 30 days, n (%)	0 (0.0%)	0 (0.0%)	N/A
Mortality within 90 days, n (%)	0 (0.0%)	0 (0.0%)	N/A
Postoperative hospital stay, days, median (range)	9 (8–20)	12 (7–88)	0.004

*Continuous variables are expressed as median with range. †Data for one patient in RDP; data for two patients in LDP are not available. CRP, C-reactive protein; LDP, laparoscopic distal pancreatectomy; N/A, not available; POD, postoperative day; RDP, robotic distal pancreatectomy.

preoperative albumin levels, and lymphocyte count. Pancreatic ductal adenocarcinoma was identified in 6 patients (35.3%) of the RDP group and 10 patients (32.3%) of the LDP group with no statistically significant difference.

Table 2 shows the comparison of intraoperative variables between RDP and LDP. Operative time for DP with spleen resection in RDP tended to be longer than that in LDP without any statistically significant differences. Thickness of the pancreatic transection line was comparable between the two groups. The use of a stapler with reinforcement in RDP was significantly higher than that in LDP (P = 0.004). There were no significant differences between RDP and LDP in conversion to open surgery or in estimated blood loss.

Regarding the postoperative outcomes (Table 3) between RDP and LDP, no significant differences were observed in the incidence of postoperative pancreatic fistula of all grades, drain amylase levels on POD 1 and 3, or the serum C-reactive protein levels on POD 1, 3, and 5. The median duration of drainage was the same in both RDP and LDP. The postoperative hospital stay in RDP was significantly shorter than that of LDP (P = 0.004). There was no significant difference regarding

Table 4. Comparison of duration of drain insertion between before January 2017 and after January 2017*

Variable	Before January 2017	After January 2017	*P*-value
Duration of drain insertion, days, median (range)	7 (3–125)	4 (3–23)	0.011
Surgical approach, *n* (%)			0.004
Robotic surgery	0 (0.0%)	17 (100.0%)	
Laparoscopic surgery	11 (35.5%)	20 (64.5%)	

*Continuous variables are expressed as median with range.

reoperation within 30 days after surgery. There were no readmissions within 30 days and no mortality within 90 days after surgery in either group.

The median duration of drain insertion before January 2017 and after January 2017 was 7 days, 4 days, respectively with significant difference ($P = 0.011$), and all cases of RDP were performed after January 2017 (Table 4).

DISCUSSION

Robotic surgery is a dominant alternative to laparoscopic surgery worldwide. This advanced approach overcomes disadvantages such as constrained range of motion, reliance on two-dimensional imaging, and the limited operative precision of laparoscopic surgery. Retrospective cohort studies reported by high-volume institutions have confirmed the safety and feasibility of RDP compared with LDP with respect to surgical outcomes. RDP is expected to be performed as a generalized surgical procedure for tumors located in the pancreatic body and tail.[3, 7]

Our hospital is located in the Tottori prefecture, which is one of the most sparsely populated areas in Japan. We average about five pancreatectomy cases per year using MIDP, including RDP or LDP, during the last decade. The European Consortium on Minimally Invasive Pancreatic Surgery registry, which aims to collect data on all minimally invasive pancreatic surgery in low and high volume centers across Europe to monitor both volume and postoperative outcomes after minimally invasive pancreatic surgery, reported that median volume of MIDP in 54 centers in 15 countries was 10 cases per year.[8] Based on this report, our hospital is regarded as a low-volume institution with respect to MIDP. Whether the safety and feasibility of RDP in low-volume hospitals such as our hospital is the same as those in high-volume hospitals remains unclear. Hence, our study was designed to evaluate the surgical outcomes of RDP compared with LDP in a low-volume institution.

This study demonstrated that there were no significant differences in the postoperative surgical outcomes between RDP and LDP except for postoperative hospital stay. The recent systematic review comparing surgical outcomes of RDP and LDP including 43 studies with 6,757 patients, found that RDP was associated with a lower conversion rate (range, 0–10.3%) and similar postoperative outcomes compared with LDP. The range of incidence of postoperative pancreatic fistula and mean estimated blood loss in RDP were 0–37.0%, 12–515 mL, respectively. The review also suggested that a potential disadvantage of RDP was the longer operative time.[9] A multicenter international propensity score–matched study in 21 European centers from six countries showed a longer duration of surgery (median 285 min in RDP versus 350 min in LDP) and lower conversion rate (6.7% in RDP versus 15.2% in LDP) in association with RDP compared with LDP. Major morbidity such as postoperative pancreatic fistula and 90-day mortality were comparable between RDP and LDP.[2] Contrary to these reports, there was no significant difference between RDP and LDP according to operative time in this study. This may result from the operative times of not only RDP but also LDP being much longer than those of high-volume centers.[2, 9] Also, because of the underpopulated area, the much longer operation time in our hospital was considered to result from the presence of only one experienced hepatobiliary–pancreatic surgeon in our hospital, who always operated with non-HBP surgeons who had participated in few HBP surgeries. Compared with previous similar cohort studies, the present study showed lesser operative blood loss and lower incidence of relevant postoperative pancreatic fistula in MIDP, which were not inferior to these outcomes in high volume centers.[10, 11] Furthermore, the favorable surgical outcomes of RDP were comparable with those of LDP in this study, which was also similar to the results reported by a systematic review or large-scale study of high-volume centers. Finally, our results suggest that RDP could be a safe and feasible procedure in a low-volume center. With respect to postoperative hospital stay, RDP was associated with shorter postoperative hospital stay than LDP, which was considered to be affected by the decreased incidence of relevant

pancreatic fistula due to change of postoperative drain management, not by surgical procedure of either RDP or LDP. In fact, the incidence of relevant pancreatic fistula of RDP tended to be lower than that of LDP. In addition, the duration of drain insertion was shorter after January 2017 and the all cases of RDP were performed after January 2017.

Our study has some limitations. This was a retrospective analysis involving a small cohort, which can generate bias. In addition, many local, low-volume institutions in Japan have no expert HBP surgeons. Therefore, a multicenter prospective study comprising low-volume centers with or without expert HBP surgeons is desirable to confirm these findings. Though RDP has been recognized as a more expensive surgery than LDP, no data on surgical costs were collected in the current study.

In conclusion, RDP can be performed as safely and effectively as LDP in a low-volume center located in a sparsely populated area.

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REFERENCES

1 Chen H, Shen Z, Ying X, Weng Y, Jiang Y, Chen H, et al. Robotic distal pancreatectomy reduces pancreatic fistula in patients without visceral obesity as compared to open distal pancreatectomy: A propensity score matching retrospective cohort study. Int J Surg. 2021;90:105960. DOI: 10.1016/j.ijsu.2021.105960, PMID: 33989824

2 Lof S, van der Heijde N, Abuawwad M, Al-Sarireh B, Boggi U, Butturini G, et al.; European Consortium on Minimally Invasive Pancreatic Surgery (E-MIPS). Robotic *versus* laparoscopic distal pancreatectomy: multicentre analysis. Br J Surg. 2021;108:188-95. DOI: 10.1093/bjs/znaa039, PMID: 33711145

3 .Müller PC, Breuer E, Nickel F, Zani S, Jr., Kauffmann E, De Franco L, et al. Robotic Distal Pancreatectomy, a Novel Standard of Care? Benchmark Values for Surgical Outcomes from 16 International Expert Centers2022.

4 Nakata K, Nakamura M. The current status and future directions of robotic pancreatectomy. Ann Gastroenterol Surg. 2021;5:467-76. DOI: 10.1002/ags3.12446, PMID: 34337295

5 Zhang X, Chen W, Jiang J, Ye Y, Hu W, Zhai Z, et al. A comparison of robotic versus laparoscopic distal pancreatectomy: a single surgeon's robotic experience in a high-volume center. Surg Endosc. 2022;36:9186-93. DOI: 10.1007/s00464-022-09402-8, PMID: 35851817

6 Bassi C, Marchegiani G, Dervenis C, Sarr M, Abu Hilal M, Adham M, et al.; International Study Group on Pancreatic Surgery (ISGPS). The 2016 update of the International Study Group (ISGPS) definition and grading of postoperative pancreatic fistula: 11 Years After. Surgery. 2017;161:584-91. DOI: 10.1016/j.surg.2016.11.014, PMID: 28040257

7 Chen JW, van Ramshorst TME, Lof S, Al-Sarireh B, Bjornsson B, Boggi U, et al.; European Consortium on Minimally Invasive Pancreatic Surgery (E-MIPS). Robot-Assisted Versus Laparoscopic Distal Pancreatectomy in Patients with Resectable Pancreatic Cancer: An International, Retrospective, Cohort Study. Ann Surg Oncol. 2023;30:3023-32. DOI: 10.1245/s10434-022-13054-2, PMID: 36800127

8 van der Heijde N, Vissers FL, Manzoni A, Zimmitti G, Balsells J, Berrevoet F, et al.; European Consortium on Minimally Invasive Pancreatic Surgery. Use and outcome of minimally invasive pancreatic surgery in the European E-MIPS registry. HPB (Oxford). 2023;25:400-8. DOI: 10.1016/j.hpb.2022.07.015, PMID: 37028826

9 van Ramshorst TME, van Bodegraven EA, Zampedri P, Kasai M, Besselink MG, Abu Hilal M. Robot-assisted versus laparoscopic distal pancreatectomy: a systematic review and meta-analysis including patient subgroups. Surg Endosc. 2023;37:4131-43. DOI: 10.1007/s00464-023-09894-y, PMID: 36781467

10 Lai ECH, Tang CN. Robotic distal pancreatectomy versus conventional laparoscopic distal pancreatectomy: a comparative study for short-term outcomes. Front Med. 2015;9:356-60. DOI: 10.1007/s11684-015-0404-0, PMID: 26271291

11 Goh BKP, Chan CY, Soh HL, Lee SY, Cheow PC, Chow PKH, et al. A comparison between robotic-assisted laparoscopic distal pancreatectomy versus laparoscopic distal pancreatectomy. Int J Med Robot. 2017;13:e1733. DOI: 10.1002/rcs.1733, PMID: 26813478