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Conversion of Robotic Distal Pancreatectomy: Predictors and Outcomes in an International Multicenter Study

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Author contributions
PS and PCM: conception and design, interpretation of data, creation of figures, drafting of article, and final approval. CK: conception and design, acquisition of data, statistical analysis, interpretation of data, creation of figures, drafting of article, and final approval. ATB, BS, JJ, FN, CG, EK, JP, CT, PSK, SKB, JPJ, OSM, AI, PCMA, IQM, UW, TK, BM, CT, FDB, VV, PG, DR, JM, MR, HL, CY, PTM, MMS, DAK, JH, UB, TH, IHMB, BPM: conception and design, interpretation of data, critical revision of the article, and final approval. Data supporting this study's findings are available on request from the corresponding author.

Conflict of interest

The authors declare no conflicts of interest. This study did not receive any grants or other external financial support.

Abstract

Objective

The aim of this study was to identify risk factors for conversion and assess its consequences on clinical outcomes after robotic distal pancreatectomy (RPD).

Summary of Background Data

RDP has gained popularity due to its lower conversion rate (3-8%) when compared to laparoscopic distal pancreatectomy (10-20%).

Methods

This retrospective multicenter study included RDPs performed at 16 international centers from May 2007 to March 2024. Perioperative outcomes of patients requiring conversion were compared to fully robotic RDP patients. Risk factors for conversion were identified by multivariable logistic regression analysis.

Results

Of 2,452 patients undergoing RDP, 75 (3.1%) required conversion to open surgery. In converted RDPs, operative time was longer (300 (243–376) vs. 180 (120–240) minutes; p<0.001), and blood loss was greater (500 (200–990) vs. 100 (50–200) ml; p<0.001). Converted patients experienced more overall complications (53% vs. 39%; p=0.017), major complications (41% vs. 25%; p<0.001), and a higher 90-day mortality (5% vs. 3%; p<0.001). Furthermore, both postoperative pancreatic fistula (35% vs. 18%; p<0.001) and delayed gastric emptying (10% vs. 3%; p<0.001) were more frequent in the conversion group. The rate of patients achieving textbook outcome was lower after conversion (57% vs. 74%; p=0.003). In the multivariable analysis, lesion size (>51mm; OR 2.86 (95% CI 1.56-5.08)), BMI (>28kg/m^2; OR 3.03 (1.75-5.30)), previous abdominal surgery (OR 2.48 (1.31-4.51)), patients outside benchmark criteria (OR 2.09 (1.19-3.72)), and age (>62 years; OR 2.21 (1.24-4.05)) were associated with conversion.

Conclusion

This international cohort study confirmed a very low conversion rate for RDP. Yet, converted cases experienced substantially impaired postoperative outcomes, highlighting the need for adequate patient selection through validated difficulty scoring systems.

Key words:
Robotic surgery; pancreatic surgery; distal pancreatectomy; conversion; clinical outcomes.

Abbreviations

ASA	American Society of Anesthesiologists
CCI	Comprehensive Complication Index
CD	Clavien-Dindo
DGE	Delayed Gastric Emptying
DP	Distal Pancreatectomy
EBL	Estimated Blood Loss
ISGPS	International Study Group of Pancreatic Surgery
LDP	Laparoscopic Distal Pancreatectomy
LOS	Length of Hospital Stay
MIPS	Minimally Invasive Pancreatic Surgery
OT	Operative Time
PACE	Pancreatic Surgery Composite Endpoint
PDAC	Pancreatic Ductal Adenocarcinoma
POPF	Postoperative Pancreatic Fistula
PPH	Postpancreatectomy Hemorrhage
RDP	Robotic Distal Pancreatectomy
TBO	Textbook Outcome

Introduction

Minimally invasive surgery has become the standard approach for most distal pancreatectomies (DP)[1–4]. Due to its superior short-term outcomes and comparable oncological results, minimally invasive pancreatic surgery (MIPS) for left-sided pathology has been established as the preferred approach for both benign and malignant indications[1,2,5]. Traditionally, MIPS has been performed laparoscopically but, recently, robotic distal pancreatectomy (RDP) has been rapidly adopted due to its advantageous learning curve and lower conversion rates compared to the laparoscopic approach[3,6,7]. Especially in technically difficult cases including malignant indications with proximity to large vessels, RDP seems to pose clear advantages over LDP with its superior versatility of surgical instruments and 3D vision[8].

Reported conversion rates from MIPS to open surgery are around 12% for all pancreatic procedures, while higher conversion rates are reported for the laparoscopic approach and malignant indications[5,9–12]. Conversions are often divided into planned and emergency conversions for reasons including adhesions, uncontrolled bleeding, vascular tumor involvement, and concerns for oncological radicality[5,9,11,13–15]. For LDP, general preoperative risk factors for conversion have been identified and include obesity, malignancy, and chronic pancreatitis. Furthermore, intraoperative risk factors include multi-organ resections and tumor proximity to vascular structures [9,14,16]. While extensive evidence exists on the impact of conversion in LDP, conversion during RDP with its associated risk factors and impact on postoperative outcomes have been poorly investigated and large, multicenter studies from high volume centers are noticeably lacking.

The aim of this study, therefore, is to identify risk factors associated with conversion of RDP and to analyze its impact on perioperative outcome within a consecutive patient series from 16 international centers with expertise in RDP.

Methods

Study Design

The study is reported according to the STROBE guidelines [17]. Sixteen high volume centers performing >50 pancreatic resections/year with a minimum experience of 40 RDPs were included. The final *Outcomes4RDP* collaborative consortium included: 10 centers from Europe (Basel, Copenhagen, Geneva, Heidelberg, Orléans, Lübeck, Modena, Pisa, Utrecht, and Zurich), five centers from the USA (Atlanta, Baltimore, Charlotte, Chicago, and Philadelphia), and one center from Asia (Shanghai)[6]. Patients operated on from the first RDP performed at each center until March 2024 were included. Ethical approval from the institutional board was obtained (BASEC ID 2023-01497).

Indication for RPD

Patients undergoing RDP with or without splenectomy for benign and malignant pancreatic diseases localized in the pancreatic body or tail, without involvement of the venous or arterial axis (Type 1 DP)[18], were included.

Data collection and outcomes

Data were retrieved from prospectively-maintained institutional databases and stored in an anonymized and secure online data management system. In addition to basic demographics, clinically relevant comorbidities (body mass index (BMI), diabetes, chronic obstructive pulmonary disease (COPD), chronic renal failure (CRF), and cardiac disease) were collected. Benchmark patients were defined as low-risk patients without significant comorbidities according to the international benchmark study[4]. In detail, exclusion criteria for benchmark cases were American Society of Anesthesiologists grade >2, chronic renal failure (Modification of diet in Renal Disease Study Group Stage >3), chronic obstructive pulmonary disease with forced expiratory volume <80% or anticoagulative medication.

Intraoperative outcomes included estimated blood loss (EBL), operative time (OT) and rate of unplanned splenectomies. Conversion was defined according to the Brescia Guidelines as an unplanned open incision apart from the incision needed for specimen extraction and further divided in planned and emergency conversion[19].

Postoperative complications were assessed using the Clavien-Dindo (CD) classification and the Comprehensive Complication Index (CCI®) to quantify the number and severity of complications for each patient up to 90 days after surgery[20–22]. Major complications were defined as CD grade IIIa or higher. Additional outcomes evaluated included reoperation rate, postoperative length of hospital stay (LOS), 90-day readmission rate, and 90-day mortality rate.

Pancreas-specific complications were defined according to the International Study Group of Pancreatic Surgery (ISGPS) and included postoperative pancreatic fistula (POPF), delayed gastric emptying (DGE), and post pancreatectomy hemorrhage (PPH)[23–25]. Textbook outcome (TBO) was defined by the absence of POPF, bile leak, PPH (ISGPS grade B/C), major complications, readmission, and in-hospital mortality and reflects optimal surgical results after DP[26]. Similar to the TBO, the Pancreatic Surgery Composite Endpoint (PACE) has been developed as a standardized measure to assess outcomes following pancreatic surgery. The PACE is considered positive if one of the following postoperative complications is present: POPF, PPH, reoperation, or reintervention. The PACE can be used to predict prolonged hospital stays and perioperative mortality[27]. To assess volume-outcome relationships, we divided centers as low or high-volume according to an annual caseload of 25 RDP.

For patients with pancreatic ductal adenocarcinoma (PDAC), the following oncologic outcomes were reported: R0 resection rate [28], lymph node harvest, and need for adjuvant chemotherapy.

Conversion Risk Score

De Ponthaud et al. introduced the preoperative conversion risk score (CRS) for minimally invasive DP. The CRS consists of six variables: male sex, body mass index >25kg/m^2, previous laparotomy, pancreatitis as initial symptom, tumor size (>40mm), and splenectomy. The CRS ranges from 0 to 7 and corresponded to a risk of conversion from 2% to 100% [29]. The accuracy of the CRS was tested in the current cohort.

Statistical analysis

Descriptive statistics were used to display the perioperative cohort characteristics. Qualitative variables were expressed as frequencies and percentages. Quantitative variables were expressed as mean and standard deviation (SD) if normally distributed and as median and interquartile range (IQR) when otherwise. Means between groups were compared with Student's t-test (pooled t-test) or the nonparametric Mann-Whitney. To compare percentages between groups, a contingency table analysis using the chi-square or Fisher's exact test was used when the frequency of events was low. To assess a volume effect, centers with less than 25% benchmark cases were compared to centers with a higher percentage of benchmark cases.

Logistic regression was then used to assess the association between predictor variables and conversion. A stepwise backward variable selection based on Aikake information criterion (AIC) was used for variable selection. Clinically relevant variables (tumor size, BMI, previous surgery, and PDAC vs. no PDAC) were fitted to the model. Multiple imputation was used to address the missing at random of tumor size and BMI for the multivariable model by using predictive mean matching. Dichotomization of predictor variables was used to aid clinical applicability. To assess impact, an additional model was run using the continuous predictor variables.

All analyses were performed using R version 4.2.3, R Core Team (2023) (R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL https://www.R-project.org/).

Results

Patient demographics

A total of 2,452 patients undergoing RDP were included in the study. 75 patients (3.1%) required conversion to open surgery, with 63 (2.6%) planned and 9 (0.4%) emergency conversions. The annual conversion rates of the cohort are shown in supplementary figure 1, Supplemental Digital Content 1, http://links.lww.com/SLA/F533. For three patients, the reason for urgency was unavailable. The reason for conversion in the remaining cases included bleeding (n=23), adhesions (n=14), oncological reasons (n=13), technical difficulties (n=13), visceral fat (n=9), and various (n=12). Converted patients were older (65 (55-73) vs. 59 (45-68) years; p=0.001), had a higher BMI (27 (24-31) vs. 24 (22-27) kg/m²; p=0.001), and more comorbidities. (**Table 1**).

Impact on intraoperative outcomes

Conversion was associated with a prolonged OT (300 (243–376) vs. 180 (120–240) minutes; p<0.001), higher EBL (500 (200–990) vs. 100 (50– 200; p < 0.001)), and a higher rate of unplanned splenectomies (6.9% vs. 0.6%; p<0.001) (**Table 2**). There were no differences in OT (325 (213–401) vs. 296 (245–375) minutes) and EBL (900 (325–1125) vs. 500 (200–945) ml) between planned and emergency conversions.

Impact on postoperative outcomes

Converted patients experienced a higher rate of overall (53% vs. 39%; p=0.017) and major complications (42% vs. 25%; p<0.001). Mortality was almost doubled in case of conversion (5% vs. 3%; p<0.001). Pancreas-specific complications such as POPF (36% vs. 19%; p<0.001) and DGE (12% vs. 3%; p<0.001) were both more frequent in the conversion group. The higher complication rate led to more reinterventions (20% vs. 4%; p<0.001) and readmissions (15% vs. 8%; p=0.058); however, reoperation rate (5% vs. 3%; p=0.384) did not differ. In converted patients with PDAC, an R0 resection was achieved in a similar proportion of patients (85% vs. 92%, p=0.505), but in converted cases lymph node yield was higher (19 (13-23) vs. 9 (4-17), p=0.001)

Looking at modern composite outcomes, the proportion of patients with a positive PACE was doubled in the conversion group (39% vs. 22%; p=0.003) and, in line with this finding, fewer patients achieved a TBO in the conversion group (57% vs. 74%; p=0.003) (**Table 2**).

Between planned and emergency conversions, there was no differences in major complications (22% vs. 22%; p=0.472), POPF (33% vs. 37%; p=1.000), reoperation rate (19% vs 19%; p=0.908) and mortality (0% vs. 3.1%; p=1.000).

Risk factors for conversion

In the multivariable analysis, age over 62 years, BMI over 28 kg/m^2, previous upper abdominal surgery, lesions larger than 51mm, and being a high risk, non-benchmark patient were significant independent factors associated with an increased conversion risk. (**Table 3**).

Furthermore, higher case volumes in overall robotic pancreatic procedures (1.9% vs. 11.8%) and RDP (0.7% vs. 6.7%) were shown to reduce conversion rates (**Figure 1**).

Conversion risk score

The CRS showed low discrimination in the RDP cohort and overestimated the conversion rate in low- and high-risk patients. For example, up to a CRS of 4 points, the actual RDP conversion rate was below 4%, while the CRS suggests a 35% risk of conversion in this cohort (**Figure 2**).

Discussion

This international multicenter study highlights a very low conversion rate of 3.1% in 2,452 patients undergoing RDP from 16 expert centers. Postoperative outcomes following conversion were significantly impaired compared to successfully completed robotic DP. For example, in converted cases, blood loss was five times higher, more unplanned splenectomies were performed, while the rate of major complications increased threefold and postoperative mortality doubled. Converted patients likewise experienced a higher incidence of pancreas-specific complications such as POPF and DGE. These clinically relevant differences underline the consequences of converted MIDP, highlighting the importance of adequate patient selection for MIPS. However, it remains unclear whether these inferior outcomes are primarily due to the initial surgical approach, the inherent complexity of the converted cases, or a combination of both. These uncertainties further emphasize the need for validated difficulty scoring systems for RDP, similar to the robotic pancreatoduodenectomy score (PD-

ROBOSCORE)[30] and ISGPS complexity grading system [31,32], which have recently been established for pancreaticoduodenectomy.

Conversions can be divided into two groups: emergency and planned. While the former are almost always due to uncontrolled bleeding and are associated with worse outcomes, planned conversions are mainly due to technical reasons such as vascular tumor involvement, oncologic concerns, difficult visualization, or adhesions [9,33–36]. In the current series, only 9 conversions were emergencies, making meaningful comparisons difficult. However, 7 of these conversions were due to uncontrolled bleeding. The largest up-to-date analysis on the topic includes patients from the American College of Surgeons National Surgical Quality Improvement Program and compared outcomes from 958 LDPs, 323 RDP to 231 converted MIDPs, and 1,414 open DPs. In line with the results of our cohort, conversion led to longer OT, increased overall and major complication rates, as well as more reoperations compared to both MIDP and ODP. Furthermore, compared to the MIDP group, 30-day mortality was significantly higher in case of conversion (0.3% vs. 2.2%)[14,30,31]. A recent meta-analysis also found impaired outcomes for converted minimally invasive pancreatic head resections in comparison to MIPD, suggesting that patient selection according to surgical complexity is of paramount importance in minimally invasive pancreatic head and body/tail resections[37].

In line with the higher rate of perioperative complications, modern composite endpoints stress the favorable postoperative outcomes and patient recovery of successfully completed RDP with a higher rate of patients achieving TBO (74% vs. 57%) and less patients with a positive PACE (22% vs. 39%). Those results are comparable to the MIDP TBO rates of 60%-70% reported in the literature [26,38,39]. Both TBO and PACE are clinically relevant composite endpoints that summarize adverse events. Moreover, the 20% difference in the current cohort highlights the potential for lower sample sizes for future prospective trials in MIPS as compared to single metric endpoints (e.g. POPF).

Regarding oncologic safety, we found that conversion had no impact on the R0 rate but lymph node harvest was higher in case of conversion, albeit within the benchmark cutoff of at least 9 lymph nodes for both groups. Furthermore, fewer converted patients with PDAC were able to receive adjuvant chemotherapy (74% vs. 50%). Unfortunately, no data were available for the current cohort to assess the impact of higher lymph node harvest and lower rate of adjuvant chemotherapy on long-term survival. The influence of the conversion on long-term PDAC outcomes should be assessed within the *Outcomes4RDP collaborative* in a follow-up study. However, a large multicenter study assessed the impact of conversion in patients with PDAC undergoing LDP. The reason for conversion was almost equally split among three groups: vascular tumor involvement, oncological concerns, and bleeding. Converted PDAC patients had a lower R0 resection rate (58% vs. 72%) a higher recurrence rate (72% vs. 55%), and a trend towards lower median overall survival (21 vs. 32 months) when compared to laparoscopically completed DP. However, since tumor proximity to vascular structures (<1cm) was the most relevant risk factor for conversion and 2/3 of all conversions were performed for oncologic reasons, the need for conversion may just as easily reflect a more advanced disease stage [40]. Therefore, their oncologic results should be interpreted with caution. In a second step, the authors compared converted cases to a matched open cohort and found similar oncologic results, stating that the inferior oncologic results rather reflect a more aggressive disease than the act of conversion [41].

Still, surgeons should be aware of their own skills and learning curve, especially when operating on anatomically difficult-to-resect PDAC or when encountering unexpected findings [42]. In such cases, an early and planned conversion should be considered to prevent serious events such as bleeding and emergency conversion. As shown in this and other studies, emergency conversion significantly impacts postoperative outcomes and consequently the chance to receive adjuvant chemotherapy. Several studies on pancreatic surgery highlight the importance of severe morbidity (and its consequently reduced rate of patients receiving adjuvant treatment) on long-term survival [43–45].

Recently, the Heidelberg group classified DP into 4 types according to level of technical difficulty. The extent of resection and taking into consideration portal vein, arterial, and multivisceral resections correlated with both intra- and postoperative outcomes and can be considered a basis for difficulty assessment in open and minimally-invasive DP[18]. A more detailed difficulty scoring system for LDP originating in Japan includes five factors: type of operation, pancreatic transection line, tumor proximity to major vessels, tumor extension to peripancreatic tissue, and left-sided portal hypertension. Based on this score, the authors suggest assigning cases to surgeons according to their level of experience. For example, a resection with a high difficulty score of 7-10 points should be reserved for proficient surgeons with an experience of 50 LDPs or more [46]. In an external validation cohort, the Japanese difficulty scoring system was shown to strongly correlate with intraoperative outcomes such as conversion rate, OT, and intraoperative blood loss [47]. While a comparable difficulty measurement for RDP is missing, several preoperative factors have been found to increase the level of surgical difficulty for RDP, namely tumors located at the neck of the pancreas and the origin of the splenic artery within the pancreatic parenchyma [48]. In the current multivariable analysis, age, BMI, lesion size, previous upper abdominal surgery, and being outside of the benchmark criteria were preoperative risk factors for conversion. We recommend to adjust the case selection according to modifiable risk factors (BMI, tumor size and previous abdominal surgery), especially in the early individual learning curve.

The recently introduced CRS aimed to classify the risk of conversion in minimally invasive DP based on six preoperatively available parameters (male sex, BMI, previous laparotomy, pancreatitis, tumor size, and planned splenectomy). In their internal evaluation, the CRS performed similarly in both the training (AUC=0.75) and validation sets (AUC=0.74). While the authors included mainly LDPs (87%) and a small proportion of RDPs (13%) for a combined MIDP conversion risk score, the main advantage of RDP was found to be a conversion rate that is three times lower. This finding has been repeatedly documented by international benchmark studies. The benchmark cutoff was 3-5% for RDP and 15-20% for LDP[4,49–51]. The differing conversion benchmark values highlight the importance of an adequate reference cutoff when interpreting the CRS (**Figure 2**). In the current RDP cohort, the CRS showed low discrimination and overestimated the true conversion rate regardless of patient risk level. Although BMI, increasing tumor size and previous surgery are risk factors for conversion in both the present analysis and the CRS, the variables were defined differently. More importantly, the robotic approach may facilitate solving difficult intraoperative situations and ultimately alter the conversion pattern. We therefore advise against applying the CRS to RDP.

Surgical experience has a significant effect on both patient selection and surgical outcomes. In the current study, conversion rates were markedly lower in high-volume RDP centers as defined by an annual case load of more than 25 RDPs. The nationwide LAELAPS training program for MIDP from the Dutch Pancreatic Cancer Group consisted of a detailed technique description, video training, and on-site proctoring. In their initial evaluation, 32 pancreatic surgeons were trained in MIDP and while more advanced tumors were successfully resected after the training program, the conversion rate could be lowered impressively from 38% to 8% [52]. In line with those findings, both surgeon volume and institutional experience were shown to impact the conversion rate in patients undergoing LDP [53,54]. For RDP, the different learning phases of competency, proficiency, and mastery were recently[6]. While the different phases of the institutional learning curve were reached relatively late (after 46 to 73 procedures), the conversion rate did not meaningfully decrease from 5.2% to 3.8%. Still, compared to LDP, the robotic approach offers a 10-15% reduced conversion rate, which translates to clinically relevant benefits in terms of morbidity and recovery for a large cohort of patients.

This study poses some limitations, due not only to its retrospective nature but because important information on the reason and timing of some conversions could not be retrieved. Furthermore, this study does not compare the outcomes of converted cases to an open cohort to assess the true value of the robotic approach. However, several randomized studies show the benefits of MIDP. In addition, due to the low conversion rate, the small size of the converted RDP group limits statistical comparison.

In conclusion, this international, multicenter cohort study found that conversion rates for RDP are low overall. Furthermore, a conversion from the robotic to an open approach has a relevant influence on clinical outcomes in terms of major morbidity and mortality. In obese patients with anatomically difficult-to-resect PDACs in particular, upcoming studies should focus on appropriate patient selection for the robotic approach and should, consequently, evaluate the effects of RDP on long-term oncologic outcomes.

Compliance with Ethical Standards

Conflict of interest: The authors declare that they have no conflict of interest.

Source of Funding: The study was funded by institutional means.

Ethical approval: All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Approval was obtained from the ethical review board of the University of Basel (BASEC ID 2023-01497).

Informed consent: Not applicable due to the nature of the study design.

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Figure 1: Impact of center specific annual case load of robotic pancreatic surgery (A) and robotic distal pancreatectomy (B). Centers were classified as high-volume if the caseload was over 25 procedures.

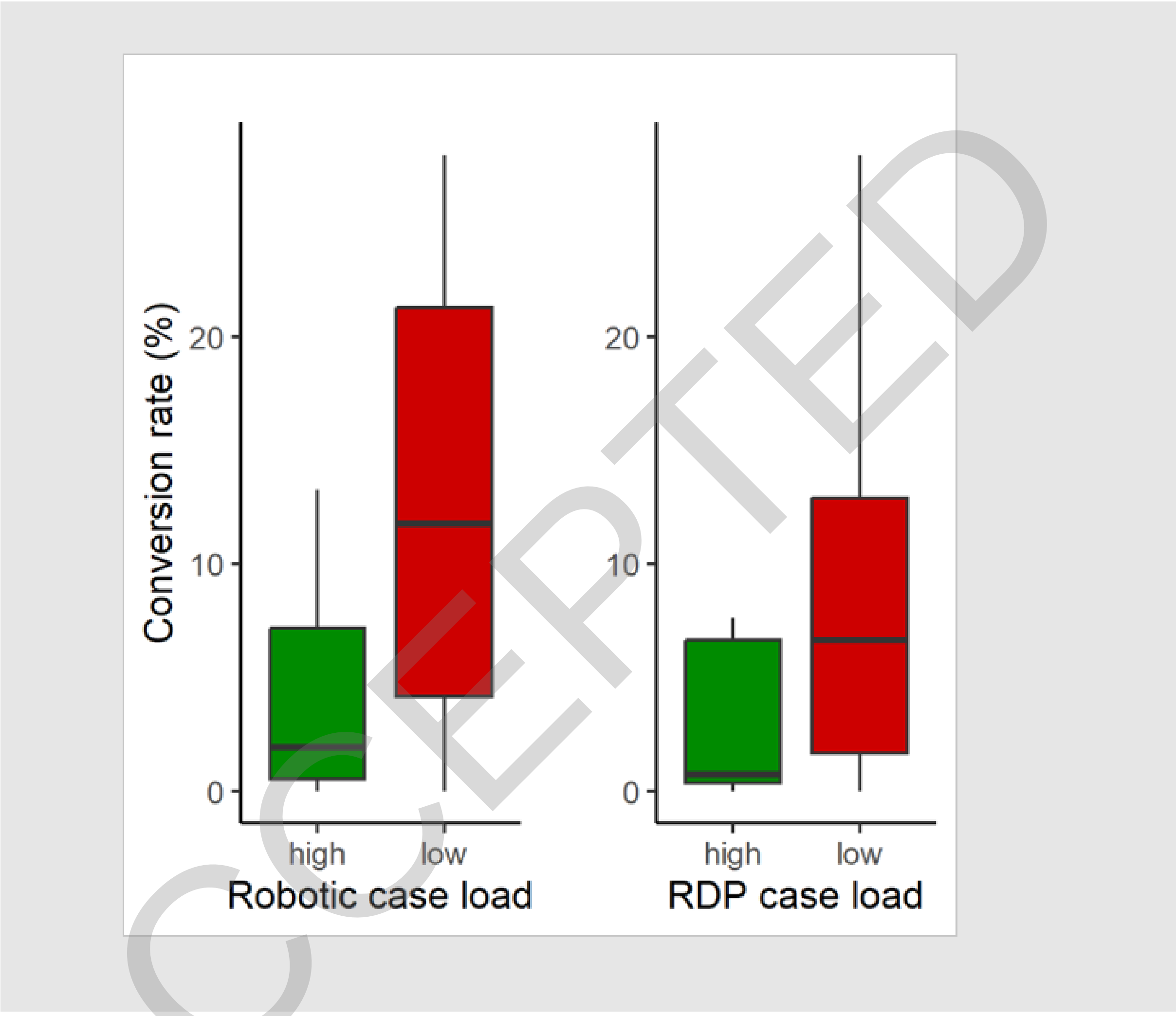

Figure 2: Conversion rate of the robotic distal pancreatectomy cohort (red) and the mainly laparoscopic cohort of the original publication (blue). Furthermore, international benchmark cutoffs for the conversion rate of laparoscopic (yellow) and robotic (green) distal pancreatectomy are depicted.

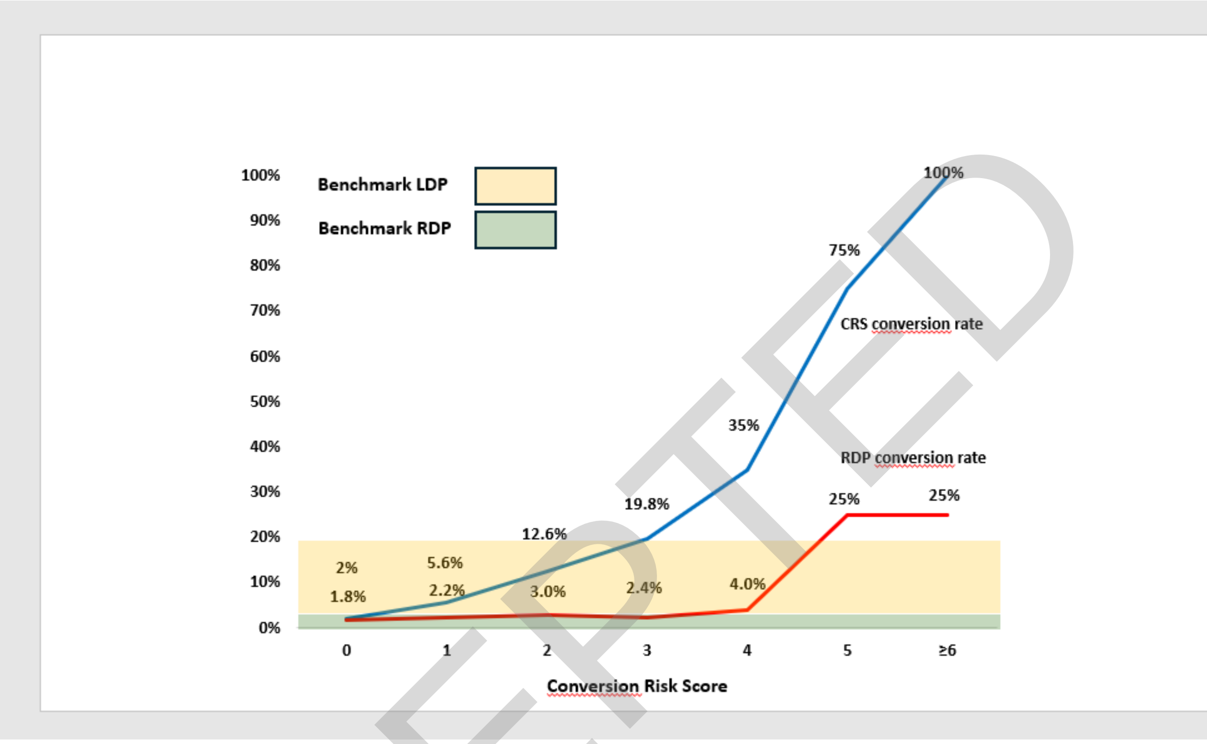

Table 1: Baseline characteristics of patients undergoing robotic distal pancreatectomy.

		Conversion		
	Overall	**No**	**Yes**	***P***
	(n= 2’452)	(n= 2’377)	(n= 75)	
Age, years	59 (46-69)	59 (45-68)	65 (56-73)	0.001
Male	1001 (41.2)	962 (40.8)	39 (52.7)	0.053
Benchmark cases*	1626 (67.0)	1601 (68.0)	25 (34.2)	<0.001
BMI, kg/m^2	24 (22-27)	24 (22-27)	27 (23-31)	0.001
ASA ≥ 3	604 (25)	567 (24)	37 (50)	<0.001
Diabetes	458 (18.8)	439 (18.6)	19 (26.0)	0.148
COPD	66 (2.7)	61 (2.6)	5 (6.8)	0.148
CRF	39 (1.6)	36 (1.5)	3 (5.2)	0.070
Cardiac disease	239 (9.8)	224 (9.5)	15 (20.3)	0.004
Anticoagulants	226 (9.3)	212 (9.0)	14 (18.9)	0.007
Smoking	491 (21.5)	463 (20.8)	28 (43.7)	<0.001
Neoadjuvant Therapy	64 (2.8)	62 (2.7)	2 (2.9)	0.284
Lesion size, mm	30 (20-45)	30 (20-44)	36 (20-60)	0.236
Duct diameter >3mm	277 (38.8)	257 (38.1)	20 (50.3)	0.207
Diagnosis				<0.001
PDAC	623 (25.6)	602 (25.5)	21 (28.0)	
NET	524 (21.5)	514 (21.8)	10 (13.3)	
IPMN	273 (11.2)	260 (11.0)	13 (13.7)	
Chronic pancreatitis	72 (3.0)	66 (2.8)	6 (8.0)	
Cystic lesions	844 (34.6)	824 (34.8)	20 (26.7)	
Other benign	49 (2.0)	48 (2.0)	1 (1.3)	
Other malignant	52 (2.1)	48 (2.0)	4 (4.3)	

Note: Data are given as n (%) and median (IQR). ASA, American Society of Anesthesiologists; BMI, Body Mass Index; COPD, Chronic Obstructive Pulmonary Disease; CRF, Chronic Renal Failure; IPMN, Intraductal Papillary Mucinous Neoplasm; NET, Neuroendocrine Tumor; PDAC, Pancreatic Ductal Adenocarcinoma.
*low-risk patients according to Müller et al.[4]

Table 2: Intra- and postoperative outcomes for robotic distal pancreatectomy cases.

		Conversion		
	Overall (n= 2452)	**No** (n=2377)	**Yes** (n=75)	***P***
Duration, min	180 (120-247)	180 (120-240)	300 (243-376)	<0.001
Blood loss, ml	100 (50-200)	100 (50-200)	500 (200-990)	<0.001
Splenectomy				<0.001
Planned	1327 (57)	1288 (57)	39 (54)	
Unplanned	18 (0.8)	13 (0.6)	5 (6.9)	
Intraoperative drain	2343 (97)	2276 (97)	67 (97)	1.000
Time to drain removal, days	7 (5-11)	7 (5-11)	8 (5-14)	0.136
Overall complications	962 (39)	922 (39)	40 (53)	0.017
Highest CD complication				0.001
2	161 (16.6)	148 (16.0)	13 (31.7)	
3a	113 (11.7)	104 (11.2)	9 (22.0)	
3b	84 (8.7)	81 (8.7)	3 (7.3)	
4a	15 (1.5)	13 (1.4)	2 (4.9)	
4b	6 (0.6)	5 (0.5)	1 (2.4)	
5	28 (2.9)	26 (2.8)	2 (4.9)	
Major complication (CD≥3a)	246 (25.4)	229 (24.6)	17 (41.5)	<0.001
POPF				<0.001
Grade B	452 (18.8)	427 (18.3)	25 (34.7)	
Grade C	14 (0.6)	13 (0.6)	1 (1.4)	
DGE				<0.001

A	34 (1.4)	30 (1.3)	4 (5.3)	
B	29 (1.2)	26 (1.1)	3 (4.0)	
C	7 (0.3)	5 (0.2)	2 (2.7)	
PPH				0.599
Grade B	18 (0.7)	17 (0.7)	1 (1.3)	
Grade C	41 (1.7)	41 (1.7)	0 (0.0)	
ERCP	52 (2.1)	49 (2.1)	3 (4.1)	0.451
Percutaneous drain	105 (4.3)	90 (3.8)	15 (20.3)	<0.001
Reoperation	73 (3.0)	69 (2.9)	4 (5.3)	0.384
LOS, days	14 (7-20)	14 (7-20)	10 (7-15)	0.016
Readmission	198 (8.1)	187 (7.9)	11 (14.7)	0.058
CCI at discharge	0 (0-8.7)	0 (0- 8.7)	8.70 (0-25.3)	<0.001
CCI after 3months	0 (0-8.7)	0 (0-8.7)	8.70 (0-26.9)	<0.001
PACE	534 (22.5)	509 (22.1)	25 (38.5)	0.003
TBO	1762 (73.5)	1723 (74.0)	39 (57.4)	0.003
Pancreatic adenocarcinoma (n=623)				
Lymph node harvest	9 (4-17)	9 (4-17)	19 (13-23)	0.001
Positive lymph nodes	0(0-1)	0 (0-1)	1 (0-2)	0.077
R0 resection	557 (91.8)	540 (92.0)	17 (85.0)	0.505
Adjuvant chemotherapy	351 (73.1)	343 (73.9)	8 (50.0)	0.066

Note: Data are given as n (%) and median (IQR).
CD, Clavien-Dindo; CCI, Comprehensive Complication Index; ERCP, Endoscopic Retrograde Cholangiopancreatography; LOS, Length of Stay; PACE, Pancreatic Surgery Composite Endpoint; POPF, Postoperative Pancreatic Fistula; PPH, Postpancreatectomy Hemorrhage; TBO, Textbook Outcome.

Table 3: Multivariable Regression Analysis

	Multivariable	
	OR (95% CI)	***P***
Intercept	0.24 (0.12–0.43)	<0.001
Age >62y	2.21 (1.24-4.05)	0.010
BMI >28 kg/m^2	3.03 (1.75-5.30)	<0.001
Previous upper abdominal surgery	2.48 (1.31-4.51)	0.047
PDAC	1.1 (0.58–2.02)	0.755
Size >51mm	2.86 (1.56-5.08)	<0.001
Non-benchmark patient	2.09 (1.19-3.72)	0.005

BMI, Body Mass Index; OR, Odds Ratio; PDAC, Pancreatic Ductal Adenocarcinoma.