



HAL
open science

Defining Benchmark Outcomes for Distal Pancreatectomy: Results of a French Multicentric Study.

Thibault Durin, Ugo Marchese, Alain Sauvanet, Safi Dokmak, Zineb Cherkaoui, David Fuks, Christophe Laurent, Marie André, Ahmet Ayav, Cloe Magallon, et al.

► To cite this version:

Thibault Durin, Ugo Marchese, Alain Sauvanet, Safi Dokmak, Zineb Cherkaoui, et al.. Defining Benchmark Outcomes for Distal Pancreatectomy: Results of a French Multicentric Study.. *Annals of Surgery*, 2023, 278 (1), pp.103-109. 10.1097/SLA.0000000000005539 . hal-03711172

HAL Id: hal-03711172

<https://u-picardie.hal.science/hal-03711172v1>

Submitted on 21 Feb 2024

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

Defining Benchmark Outcomes for Distal Pancreatectomy

Results of a French Multicentric Study

Thibault Durin, MD,* Ugo Marchese, MD,† Alain Sauvanet, MD, PhD,‡
Safi Dokmak, MD,‡ Zineb Cherkaoui, MD,‡ David Fuks, MD, PhD,†
Christophe Laurent, MD, PhD,§ Marie André, MD,|| Ahmet Ayav, MD, PhD,||
Cloe Magallon, MD,¶ Olivier Turrini, MD, PhD,¶ Laurent Sulpice, MD, PhD,#
Fabien Robin, MD, PhD,# Philippe Bachellier, MD, PhD,**
Pietro Addeo, MD, PhD,** François-Régis Souche, MD, PhD,††
Thomas Bardol, MD,†† Julie Perinel, MD, PhD,‡‡ Mustapha Adham, MD, PhD,‡‡
Stylianios Tzedakis, MD,† David J. Birnbaum, MD, PhD,§§ Olivier Facy, MD, PhD,|||
Johan Gagniere, MD, PhD,¶¶ Sébastien Gaujoux, MD, PhD,##
Ecoline Tribillon, MD,*** Edouard Roussel, MD,††† Lilian Schwarz, MD, PhD,†††
Louise Barbier, MD, PhD,‡‡‡ Alexandre Doussot, MD, PhD,§§§
Nicolas Regenet, MD,|||| Antonio Iannelli, MD, PhD,¶¶¶
Jean-Marc Regimbeau, MD, PhD,#### Guillaume Piessen, MD, PhD,****
Xavier Lenne, Msc,†††† Stéphanie Truant, MD, PhD,*
and Mehdi El Amrani, MD, PhD*✉

Objective: Defining robust and standardized outcome references for distal pancreatectomy (DP) by using Benchmark analysis.

Background: Outcomes after DP are recorded in medium or small-sized studies without standardized analysis. Therefore, the best results remain uncertain.

Methods: This multicenter study included all patients undergoing DP for resectable benign or malignant tumors in 21 French expert centers in pancreas surgery from 2014 to 2018. A low-risk cohort defined by no significant comorbidities was analyzed to establish 18 outcome benchmarks for DP. These values were tested in high risk, minimally invasive and benign tumor cohorts.

Results: A total of 1188 patients were identified and 749 low-risk patients were screened to establish Benchmark cut-offs. Therefore, Benchmark rate for mini-invasive approach was $\geq 36.8\%$. Benchmark cut-offs for postoperative mortality, major morbidity grade $\geq 3a$ and clinically significant pancreatic fistula rates were 0% , $\leq 27\%$, and $\leq 28\%$, respectively. The benchmark rate for readmission was $\leq 16\%$. For patients with pancreatic adenocarcinoma, cut-offs were $\geq 75\%$, $\geq 69.5\%$, and $\geq 66\%$ for free resection margins (R0), 1-year disease-free survival and 3-year overall survival, respectively. The rate of mini-invasive approach in high-risk cohort was lower than the Benchmark cut-off (34.1% vs $\geq 36.8\%$). All Benchmark cut-offs were respected for benign tumor group. The proportion of benchmark cases was correlated to outcomes of DP.

From the *Department of Digestive Surgery and Transplantation, Lille University Hospital, Lille, France; †Department of Digestive, Hepatobiliary and Pancreatic Surgery, Cochin Teaching Hospital, AP-HP, Université de Paris, Paris, France; ‡Department of HBP Surgery, AP-HP, Hôpital Beaujon, University of Paris, Clichy, France; §Department of Digestive Surgery, Centre Magellan—CHU Bordeaux, Bordeaux, France; ||Department of HBP Surgery, Nancy University Hospital, Nancy, France; ¶Department of Oncological Surgery, Institut Paoli Calmettes, Marseille University, Marseille, France; #Department of Hepatobiliary and Digestive Surgery, University Hospital, Rennes 1 University, Rennes, France; **Hepato-Pancreato-Biliary Surgery and Liver Transplantation, Pôle des Pathologies Digestives, Hépatiques et de la Transplantation, Hôpital de Hautepierre-Hôpitaux Universitaires de Strasbourg, Université de Strasbourg, France; ††Department of Surgery, Hôpital Saint Eloi, Montpellier, France; ‡‡Department of Digestive Surgery, Hôpital Edouard Herriot, Lyon, France; §§Department of Digestive Surgery, Hôpital Nord, Assistance Publique-Hôpitaux de Marseille, Aix-Marseille University, Marseille, France; |||Department of Digestive and Surgical Oncology, University Hospital, Dijon, France; ¶¶Department of Digestive and Hepatobiliary Surgery—Liver transplantation, University Hospital Clermont-Ferrand, Clermont-Ferrand, France; ##Department of Hepato-Biliary and Pancreatic Surgery and Liver Transplantation, AP-HP, Pitié-Salpêtrière Hospital, Paris, France; ***Department of Digestive, Oncologic and Metabolic Surgery, Institut Mutualiste Montsouris, Université de Paris, Paris, France; †††Department of Digestive Surgery, Rouen University Hospital and Université de Rouen Normandie, Rouen, France; ‡‡‡Department of Liver Transplant

and Surgery, Hôpital Trousseau, Tours, France; §§§Department of Digestive Surgical Oncology, University Hospital of Besançon, Besançon, France; ||||Department of Digestive Surgery, Nantes Hospital, Nantes, France; ¶¶¶Digestive Surgery and Liver Transplantation Unit, University Hospital of Nice, Nice, France; ####Department of Digestive Surgery, Amiens University Medical Center and Jules Verne University of Picardie, Amiens Cedex, France; ****Department of Digestive and Oncological Surgery, Claude Huriez University Hospital, Lille, France; and ††††Department of Medical Information, Lille University Hospital, Lille, France.

✉mehdi.elamrani@hotmail.fr.

T.D. and U.M. are co-first authors.

The current study included 21 high-volume centers in France. One or more authors from each center were listed in authorship and all individuals met the 3 following guidelines: authors make substantial contributions to conception and design, and/or acquisition of data, and/or analysis and interpretation of data; authors participate in drafting the article or revising it critically for important intellectual content; authors give final approval of the version to be published.

The authors report no conflicts of interest.

Supplemental Digital Content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website, www.annalsofsurgery.com.

Centers with a majority of low-risk patients had worse results than those operating complex cases.

Conclusion: This large-scale study is the first benchmark analysis of DP outcomes and provides robust and standardized data. This may allow for comparisons between surgeons, centers, studies, and surgical techniques.

Keywords: benchmark, distal pancreatectomy, outcomes

Distal pancreatectomy (DP) is commonly performed for corporeocaudal pancreatic tumors, especially for pancreatic ductal adenocarcinoma (PDAC). DP is considered a less complex procedure with lower morbidity and mortality rates than reported after pancreaticoduodenectomy (PD).^{1,2} However, data from nationwide studies suggest that postoperative mortality after DP may occur in up to 3% of the cases.³ Recently, minimally invasive distal pancreatectomy (MIDP) have been reported as improving postoperative outcomes as compared to open PD without any difference regarding oncological outcomes.⁴⁻⁶

Despite these findings, DP remains a highly complex procedure. Therefore, some authors suggest that centralization of pancreatic surgery should be mandatory to improve outcomes.⁷⁻⁹ However, the findings of recent nationwide studies indicate that centralization for DP may be unnecessary as there was no evidence to indicate that hospital volume affected DP outcome.³

Nevertheless, establishing standardized key metrics in patients who undergo DP seems to be crucial. Among these metrics, mortality alone is no longer sufficient to define surgical standards and other key parameters, such as intraoperative and oncological data, are usually ignored.^{8,10} Benchmarking is a quality improvement tool in manufacturing and economy aimed to define the best (benchmark) results and consider them as reference.¹¹ Benchmark outcomes have been previously investigated for various procedures and the relevance of establishing a benchmark for surgical outcomes was recently defined by an international expert consensus.¹²⁻¹⁹

To date, however, no specific benchmark cut-offs have been established for DP. As DP benchmarking may provide different results than other pancreatic resections, we aimed to investigate the benchmark cut-offs of this procedure in a multicenter survey of a French cohort comprising low-risk patients undergoing DP in high-volume centers.

METHODS

Study Population

This study followed a standardized methodology to establish benchmark cut-offs, as reported elsewhere.¹⁹ We included patients aged 18 years or older who underwent planned DP ± splenectomy, by open or minimally invasive approach for resectable malignant or benign pancreatic tumors between 2014 and 2018. Among these patients, we identified a low-risk subgroup to establish a benchmark cohort using preoperative criteria¹⁹ (Supplemental Digital Content, Table S1, <http://links.lww.com/SLA/D931>). We excluded patients who underwent extended DP as defined by the consensus of the International Study Group for Pancreatic Surgery (ISGPS),²⁰ patients with borderline or locally advanced tumors, palliative resection, or emergency surgery. The centers were assessed for eligibility, and we focused on high-volume centers defined as those performing more than 20 pancreatectomies per year, as previously

validated.²¹ The collaborative group included 21 high-volume French centers.

Definition of Variables and Study Outcomes

Demographic data [age, sex, weight loss, body mass index (BMI), World Health Organisation score, comorbidities, American Society of Anesthesiologists (ASA) score] and biological and radiological data were exhaustively collected. Clinicopathological (histologic classification, degree of differentiation, and resection

TABLE 1. Patients Characteristics

Variables	n (%)
Age	59.9 ± 15.6
Sex	
Male	511 (43)
Female	677 (57)
BMI	25.8 ± 5.1
ASA score	
ASA 1	288 (24.2)
ASA 2-3	895 (75.5)
ASA 4	5 (0.4)
Tumor type	
Malignant	708 (59.6)
PDAC	364 (31)
NET	259 (22)
Metastasis	46 (3.8)
Others	39 (3.3)
Benign	480 (40.4)
IPMN	128 (10.7)
Cystadenoma	138 (11.6)
Pseudocyst	30 (2.5)
Others	184 (15.5)
Intraoperative data	
Procedure	
DP without splenectomy	288 (24.3)
DP with splenectomy	614 (51.6)
Warshaw procedure	286 (24.1)
Mini-invasive	565 (47.5)
Laparoscopy	496 (87.8)
Robotic	69 (12.2)
Open conversion	66 (11.7)
Operation time (min)*	200 ± 77
Intraoperative blood transfusion	55 (4.6)
Blood loss (ml)*	223 ± 413
Postoperative data	
Intensive care unit stay	222 (18.7)
Hospital stay (d)*	14.8 ± 15.4
Clavien-Dindo grade ≥ IIIa	
At 3 mo	92 (11)
At 6 mo	47 (7.1)
At 9 mo	44 (7.2)
At 12 mo	43 (7.3)
CR-POPF (grades B or C)	181 (15.2)
Grade B POPF	151 (12.7)
Grade C POPF	30 (2.5)
Severe postoperative bleeding grade ≥ 3a	27 (2.3)
90-day mortality	13 (1.1)
Hospital readmission rate	190 (16)
Oncological outcomes for PDAC (n = 364)	
Resection margin status (R0)	306 (84.1)
1-year overall survival	333 (91.5)
3-year overall survival	288 (79.1)
1-year disease-free survival	138 (76.4)
Number of lymph nodes resected*	16.7 ± 10.4

*Mean ± SD.

IPMN indicates intraductal papillary mucinous neoplasm; NET, neuroendocrine tumor.

margins' status) and operative characteristics (time, blood loss, surgical approach, surgical technique) were also analyzed. Postoperative complications were recorded according to the Clavien-Dindo classification.²² Major morbidity was defined as Clavien-Dindo \geq IIIa at 3, 6, 9, and 12 months postoperatively. Pancreas-specific postoperative complications were defined according to the ISGPS guidelines.²³⁻²⁵ Mortality was defined as in-hospital death or death within 90 days of surgery. For patients with PDAC, we also determined oncological quality indicators, including histopathological data, overall and disease-free survivals. regarding the resection margin status, R0 was defined as free margin \geq 1 mm.

Benchmark Definition

Eighteen intraoperative and postoperative variables were used to define benchmark outcomes in the subgroup of patients with low preoperative risk. As recommended by the International Expert Delphi Consensus,¹⁹ we defined benchmarks as the 75th percentile of the median outcome parameters of the participating centers. For variables with a lower value associated with worse outcomes (R0 status, number of lymph nodes, and survival data), benchmark was defined as the 25th percentile. To evaluate the robustness of this methodology, we tested benchmark cut-offs in patients undergoing MIDP, DP for benign tumors and high-risk patients.

To evaluate the correlation between the proportion of benchmark cases and outcomes after DP, we also stratified centers according to the rates of benchmark and nonbenchmark cases.

Statistical Analysis

Categorical variables were presented as percentage values and absolute numbers (of patients) and were analyzed using the χ^2 or the Fisher exact test. Continuous variables were expressed as mean \pm SD or median. Differences between the groups were analyzed using the Mann-Whitney *U* test. A 2-tailed *P* value $<$ 0.05 was considered to indicate statistical significance. All statistical analyses were performed using Stata, version 13 STATA 13 (StataCorp, College Station, TX, USA)..

RESULTS

Patients' Characteristics

We collected data from 1188 patients who underwent DP at 21 high-volume centers in France over the study period. The mean age of the patients was 59.9 years, and 57% were female. The mean BMI was 25.8 kg/m² and 61% of patients had an ASA score of 2. The mean operation time was 200 \pm 77 min. Regarding surgical approach, nearly half of the patients (47%) underwent mini-invasive DP, but the procedure was converted to open DP for 11% of these patients (Table 1).

Regarding indications, most patients underwent DP for malignant tumors (60%). Among these patients with oncological indication, the majority underwent DP for PDAC (31%) or neuroendocrine tumors (22%). Among patients with PDAC (*n* = 364), the majority (53%) had T3 disease.

The most common surgical procedure was DP with splenectomy (51%), followed by spleen-preserving DP with resection (Warshaw procedure—24%) or preservation (Kimura procedure—24%) of spleen vessels. Postoperatively, 13 deaths occurred within 90 days after DP and the mortality rate was 1.1%. Furthermore, 17% of patients experienced major complications (Clavien-Dindo score \geq IIIa), mostly attributed to a clinically relevant postoperative pancreatic fistula (CR-POPF). For patients with PDAC, the rate of positive margins (R1) was 15%

and the mean number of resected lymph nodes was 16 \pm 10. Further baseline data of the cohort are shown in Table 1.

Benchmark Analysis

Based on data of 749 low-risk patients, 18 benchmark cut-offs were established. The data are presented in Table 2. The benchmark rate for the minimally invasive approach was \geq 36.8%. The benchmark cut-off value for postoperative mortality was 0%. Regarding morbidity, major morbidity grade \geq 3 and CR-POPF rates were \leq 27% and \leq 28%, respectively. Notably, the benchmark rate for readmission was \leq 16%. Cut-off values for patients with PDAC were \geq 75%, \geq 88%, and \geq 66% for free resection margins (R0), 1-year, and 3-year overall survival, respectively.

Validation of Benchmark Cut-offs

To evaluate the validity of the benchmark cut-off values, 3 groups of patients were established. The related patient characteristics and perioperative data are shown in Table 3. High-risk patients were more likely to be older (*P* $<$ 0.001), have more comorbidities (*P* $<$ 0.001), and a higher BMI (*P* $<$ 0.001) than low-risk patients. In addition, DP in high-risk patients was associated with a high rate of intraoperative blood transfusion (6.6% vs 3.5%, *P* = 0.012) and increased blood loss (296 \pm 531 vs 181 \pm 318, *P* $<$ 0.001). Postoperative mortality was significantly higher in the high-risk group than in the low-risk group (2.1% vs 0.5%, *P* = 0.045). However, major complications and CR-POPF rates were comparable between groups. When analyzing oncological data, survival rates were significantly worse in high-risk patients (59.2% vs 95.1% for 1-year survival rate, *P* = 0.002).

We tested benchmark cut-offs established among the low-risk patient group in cohorts of patients who underwent mini-invasive DP, those who underwent DP for benign tumors, and those in the high-risk cohort (Table 4). The rate of MIDP in the high-risk group reached the benchmark cutoff (34.1% vs \geq 36.8%). Furthermore, the median length of hospital stay in high-risk patients reached the benchmark cut-off of 13 days. Despite the higher rates of postoperative complications in high-risk patients, all defined outcome parameters were consistent with the benchmark cut-off values. Similarly, we assessed the benchmark cut-offs in a subgroup of

TABLE 2. Outcome Benchmark After DP in Low-risk Patients

	Benchmark Cut-off (%)
<i>n</i> (%)	749 (63)
Intraoperative data	
Mini-invasive	\geq 36.8
Open conversion	\leq 20.0
Operation time (min)	\leq 232
Intraoperative blood transfusion	\leq 5.9
Postoperative data	
Intensive care unit stay	\leq 25
Hospital stay (d)	\leq 13
Postoperative morbidity	
Clavien-Dindo grade \geq IIIa at 3 mo	\leq 27.3
CR-POPF (grades B or C)	\leq 28.6
Grade B POPF	\leq 27.8
Grade C POPF	\leq 5.3
Severe postoperative bleeding grade \geq 3a	\leq 2.8
90-day mortality	0.0
Hospital readmission rate	\leq 16.7
Oncological outcomes for PDAC	
Resection margin status	R0 \geq 75.9
1-year overall survival	\geq 88.3
3 years overall survival	\geq 66.7
1-year disease-free survival	\geq 69.5

TABLE 3. Comparison of Patient Characteristics and Outcomes Between Low-risk Patients and Validation Cohorts

Variable	Low-risk Patients, n (%)	Mini-invasive, n (%)	P	High-risk Patients, n (%)	P	Benign Group, n (%)	P
Age*	57.6 ± 15.1	57.7 ± 16.9	0.444	64 ± 15.7	<0.001	56.4 ± 16.2	0.384
Sex							
Male	272 (36.3)	215 (38)	0.676	239 (54.4)	<0.001	173 (36.0)	
Female	477 (63.7)	350 (62)		200 (45.6)		307 (64)	0.875
BMI*	24.8 ± 4.1	25.7 ± 5	0.026	27.5 ± 6.2	<0.001	25.2 ± 5.3	<0.001
ASA score							
ASA 1	268 (35.8)	170 (30)	<0.001	20 (4.6)	<0.001	143 (30.4)	<0.001
ASA 2	481 (64.2)	344 (60.8)		247 (56.3)		275 (58.4)	
ASA 3	0	49 (8.7)		167 (38)		52 (11)	
ASA 4	0	2 (0.4)		5 (1.1)		1 (0.2)	
Intraoperative data							
Laparoscopy	361 (48.1)	496 (87.7)	—	135 (30.8)	—	252 (52.5)	—
Open conversion	36 (9.9)	62 (12.5)	—	26 (19.3)	—	24 (9.5)	—
Mini-invasive	412 (55)	565 (100)	—	153 (34.9)	—	275 (57.3)	—
Open conversion	43 (10.4)	70 (11.8)	—	27 (17.6)	—	26 (9.5)	—
Operation time (min)*	198 ± 73	193 ± 74	0.102	204 ± 86	0.446	191 ± 71	0.107
Intraoperative blood transfusion	26 (3.5)	11 (2)	0.104	29 (6.6)	0.012	25 (5.2)	0.134
Blood loss (ml)*	181 ± 318	176 ± 334	0.355	296 ± 531	<0.001	190 ± 348	0.951
Postoperative data							
Intensive care unit stay	118 (15.7)	79 (14.1)	0.413	105 (23.9)	0.001	70 (14.6)	<0.001
Hospital stay (d)*	14.0 ± 14.4	12.1 ± 10.7	<0.001	16.1 ± 17	<0.001	13.6 ± 12.4	<0.001
Clavien-Dindo grade ≥ IIIa							
At 3 mo	64 (12.1)	38 (9.3)	0.185	28 (9.3)	0.599	51 (14.4)	0.085
At 6 mo	31 (7.4)	20 (6.2)	0.511	16 (6.5)	0.836	17 (6.5)	0.000
At 9 mo	31 (7.9)	22 (7.5)	0.819	13 (6)	0.607	18 (7.5)	0.000
At 12 mo	27 (7.1)	16 (5.6)	0.437	16 (7.8)	0.910	23 (10)	0.002
CR-POPF (grades B or C)	110 (14.7)	74 (13.2)	0.452	71 (16.2)	0.459	67 (13.9)	0.737
Grade B POPF	92 (12.3)	57 (10.2)	0.238	59 (13.5)	0.533	58 (12.1)	0.930
Grade C POPF	18 (2.4)	17 (3)	0.481	12 (2.7)	0.711	9 (1.9)	0.542
Severe postoperative bleeding grade ≥ 3a	15 (2)	12 (2.1)	0.858	12 (2.7)	0.404	7 (1.5)	0.486
90-day mortality	4 (0.5)	2 (0.4)	0.585	9 (2.1)	0.045	3 (0.6)	0.762
Hospital readmission rate	105 (14)	81 (14.4)	0.814	85 (19.4)	0.013	72 (15)	0.319
Oncological outcomes for PDAC (n = 364)							
Resection margin status (R0)	169 (85.8)	105 (85.4)	0.583	137 (83)	0.507	—	—
Survival at 1 y	189 (95.1)	115 (92.6)	0.979	103 (59.2)	0.002	—	—
Survival at 3 y	160 (81.2)	93 (75.6)	0.562	95 (57.5)	0.003	—	—
Disease-free survival	84 (48.3)	51 (44.7)	0.556	54 (35.5)	0.020	—	—
Number of lymph nodes resected*	17.1 ± 11.6	14.2 ± 9	0.031	14.3 ± 9.6	0.015	—	—

*Mean ± SD.

IPMN indicates intraductal papillary mucinous neoplasm; NET, neuroendocrine tumor; PDAC, pancreatic ductal adenocarcinoma.

patients who underwent DP for benign tumors. All the benchmark cut-offs were fulfilled in this subgroup.

Correlation Between the Rate of Benchmark Cases and Outcomes After DP

The proportion of benchmark cases varied significantly between centers, ranging from 9% to 74% (Fig. 1). Interestingly, we found no correlation between the hospital volume and the proportion of benchmark cases ($r = 0.127$, $P = 0.583$). The rate of CR-POPF was not correlated with the proportion of benchmark cases in the low-risk cohort ($r = -0.209$, $P = 0.363$) (Fig. 2). This trend was observed in patients that underwent MIDP, those with benign tumors and high-risk patients. Regarding major complications, the proportion of benchmark cases tended to be correlated with the rate of severe complications (Clavien-Dindo ≥ IIIa) in the low-risk cohort ($r = 0.358$, $P = 0.112$). Interestingly, this correlation was significant in the MIDP ($r = 0.479$, $P = 0.028$), benign ($r = 0.449$, $P = 0.041$), and high-risk cohorts ($r = 0.466$, $P = 0.033$) (Fig. 3). In other words, centers with a majority of low-risk patients had worse results than those operating complex cases.

DISCUSSION

To date, this cohort represents one of the largest reported series establishing benchmark outcomes after DP. The previous application of benchmarks in pancreatic surgery has shown interesting results when analyzing the criteria for quality after PD.^{17,18} Even if DP is associated with a lower grade of major postoperative morbidity and mortality than other pancreatic procedures, it remains a complex procedure and its best achievable results should be determined.

Among the surgical benchmark values, the benchmark mortality rate was 0%. This finding confirms that postoperative mortality after DP tended toward 0 in high-volume centers.^{2,26} Compared to previously reported data on PD performed with or without portal venous resection, these results were particularly better.^{17,18} Concerning oncological benchmark values, the 1-year disease-free survival after DP for PDAC was ≥ 69.5% and the minimal harvested lymph node number was 9, confirming that oncological results after DP were better than those after PD even if the number of harvested lymph nodes was lower.^{27,28}

The benchmark values were then compared to the median outcome values in different subgroups, that is, patients with high-risk morbidity due to poor preoperative general status

TABLE 4. Examples of Benchmark Comparisons in 3 Different DP Cohorts: High-risk Patients, Mini-invasive and Benign Tumors

	Benchmarks (%)	Mini-invasive (%)	Benign Tumors (%)	High Risk (%)
n (%)	749 (63)	565 (47.5)	480 (40)	439 (37)
Intraoperative data				
Mini-invasive	≥ 36.8	100	54.4	34.14
Open conversion	≤ 20.0	16	7.1	3.5
Operation time (min)	≤ 232	210	210	205
Intraoperative blood transfusion	≤ 5.9	0.0	0.0	4.3
Postoperative data				
Intensive care unit stay	≤ 25	5.0	10.0	14.6
Hospital stay (d)	≤ 13	9	11.5	13
Postoperative morbidity				
Clavien-Dindo grade ≥ IIIa at 3 mo	≤ 27.3	16.7	16.7	14.3
CR-POPF (grades B or C)	≤ 28.6	12.9	13.6	17.4
Grade B POPF	≤ 27.8	11.1	13.6	13.6
Grade C POPF	≤ 5.3	0.0	13.6	0.0
Severe postoperative bleeding grade ≥ 3a	≤ 2.8	0	0	0
90-day mortality	0.0	0	0	0
Hospital readmission rate	≤ 16.7	11.8	13.3	14.3
Oncological outcomes for PDAC				
Resection margin status	R0 ≥ 75.9	100	—	100
1-year overall survival	≥ 88.3	100	—	93.3
3 years overall survival	≥ 66.7	97.4	—	66.7
1-year disease-free survival	≥ 69.5	80.7	—	80

Variables are expressed as a median.

(high-risk cohort), patients who underwent surgery for benign disease, and patients who underwent a minimally invasive procedure. Along with the results in the high-risk patients cohort, our study confirmed that postoperative courses were associated with a longer length of stay and a higher rate of severe complications, though without overcoming the benchmark cut-off. In this subgroup, the cut-off for mortality remained at 0%, as in the low-risk cohort. Thus, the benchmark cut-off of mortality seemed to be poorly affected by patient preoperative general status and once again differed from the results observed after PD. This observation confirmed that these 2 procedures had to be considered separately. However, the oncological outcomes were significantly worse for patients with PDAC in this subgroup than for those in the benchmark group, possibly due to lower exposure to adjuvant chemotherapy.²⁹ Another explanation is that poor performance status could be associated with a more advanced disease. To avoid patient heterogeneity, we excluded all patients with borderline or locally advanced tumors, and those who received preoperative chemotherapy.

The benchmark rate for the use of a minimally invasive approach was ≥ 36.8%. MIDP is nowadays a well-evaluated procedure and prospective multicenter studies confirmed both its safety and its oncological equivalence to open DP.^{5,30} In the current study, about half of the patients underwent a minimally invasive first approach and its use slightly increased over time. Nevertheless, the median length of stay after DP remained particularly high. This could be explained by the fact that more than half of the patients underwent open DP. In the recent LEOPARD study, the laparoscopic approach was associated with a reduced hospital stay compared with the open group. However, even in the MIDP subgroup, the median length of stay was high.³⁰ These findings suggest differences in local routine and standard approaches between centers.

We found that the benchmark cut-off of admission in the intensive care unit was still high, but both definition and use of intensive care unit vary between centers. Unsurprisingly, we found that high-risk patients were more likely to be admitted to intensive care units compared to other subgroups. Moreover, postoperative outcomes after DP in high-risk patients were particularly worse, suggesting a correlation between the occurrence of severe complications and admission to the intensive care unit. Similarly, a recent study from the multi-institutional National Surgical Quality database demonstrated that patients without immediate postoperative admission to the intensive care unit had a very low risk of failure-to-rescue.³¹

Although outcomes after PD are strongly correlated to hospital volume, this was not so obvious for DP.³ In this study, the rates of severe postoperative complications correlated with the proportion of benchmark cases but not with the volume of pancreatectomies. In other words, the rate of major complications increased with the increase in the rate of low-risk cases. Thus, centers operating on a high proportion of difficult cases, had better outcomes. As suggested in previous studies, the difference observed in postoperative outcomes between centers might be due to better management of postoperative complications in centers used to manage with more complex patients.^{17,32} Therefore, the distinction between low-risk and high-risk patients allows to establish the case-mix of centers which may be used as a novel tool of quality of care. For this, an international expert

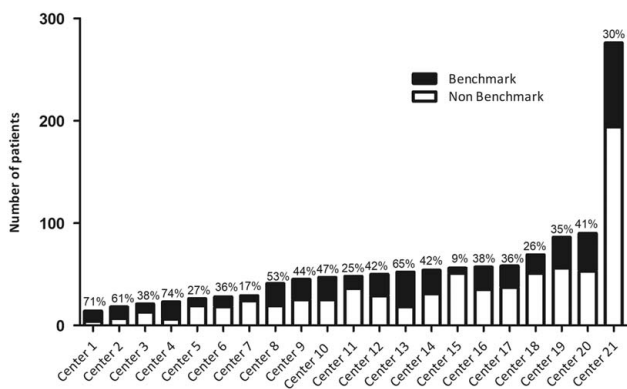


FIGURE 1. The proportion of benchmark cases across the 21 centers.

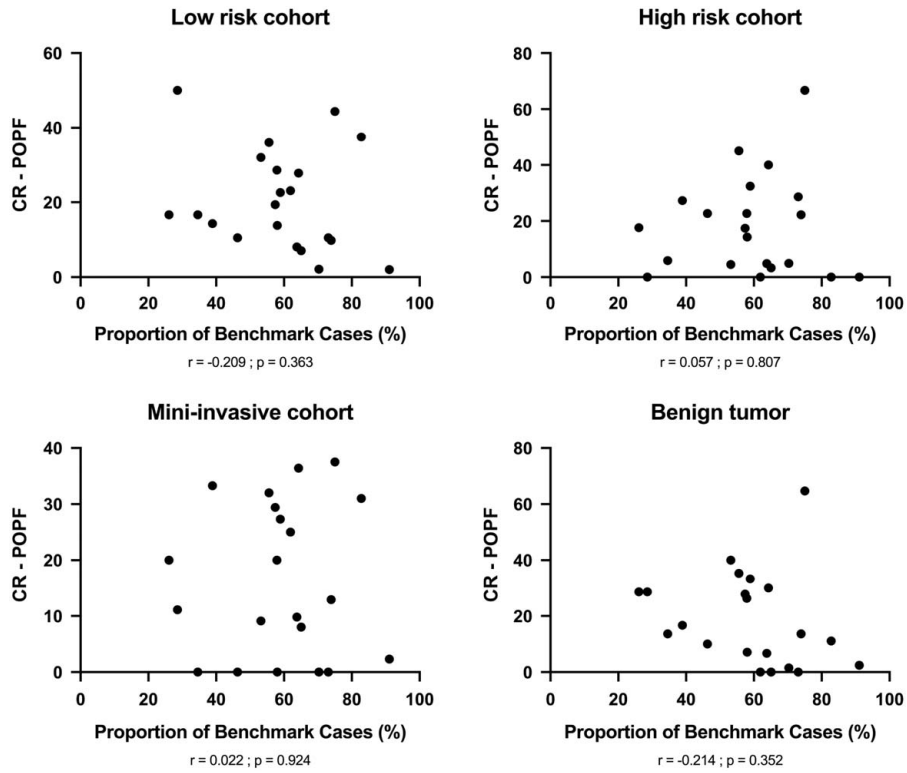


FIGURE 2. Correlation between the proportion of benchmark cases and clinically relevant postoperative pancreatic fistula rates.

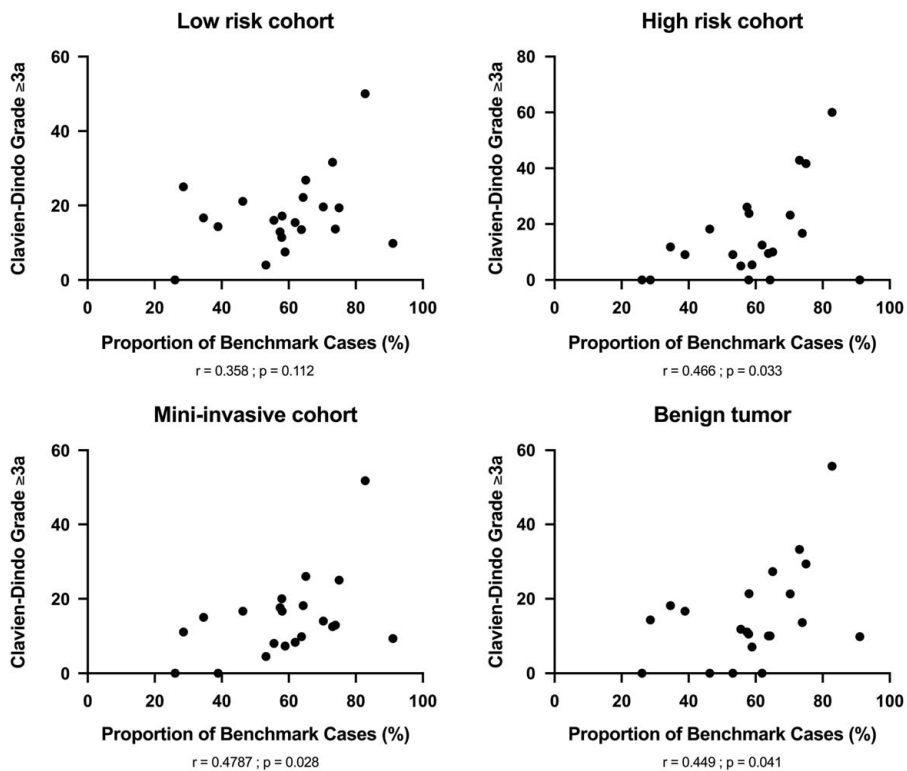


FIGURE 3. Correlation between the proportion of benchmark cases and major complications rates (Clavien-Dindo $\geq 3a$).

Delphi consensus recommended to establish benchmarks in low-risk patients according to medical and surgical comorbidities.¹⁹ The definition of these parameters are consistent with the results of previous studies that identified diabetes, cardiac, pulmonary, and renal diseases as predictors of major morbidity after pancreatectomy.⁹

This study has limitations owing to its retrospective design. First, the definition of low-risk profile focused only on preoperative feature and did not include intraoperative parameters. However, these data could impact outcomes after DP. Second, the perioperative management could be different between centers. However, only high-volume centers were included in the current study precisely in order to minimize the possible inhomogeneity in the perioperative management. We believe that high-volume status is a proxy for structural differences such as staffing level, availability of advanced technology, and processes of care. These hospital attributes would provide a similar environment to manage major complications. Also, postoperative complications were recorded according to Clavien-Dindo classification, which provides uniformity of the complications recording process. Moreover, specific complications of pancreatic surgery were defined according to international guidelines of ISGPS. Third, the average number of patients included per center was low and most centers contributed <10 DPs per year. This could be explained by the selection criteria of the current study focusing only on patients undergoing “simple” resection to define the benchmarking cases. Despite these limitations, our study used a large, high-quality, national database and was the first to define the benchmark cut-off after DP.

CONCLUSIONS

In conclusion, this large-scale study is the first benchmark analysis of DP outcomes and provides robust and standardized data. This may allow for comparisons between surgeons, centers, studies, and surgical techniques. Furthermore, it may improve patient allocation to high-volume expert centers for high-risk profiles. The proportion of benchmark cases may reflect the results more accurately than the center volume or morbidity or mortality rates.

REFERENCES

1. Pratt W, Maithel S, Vanounou T, et al. Postoperative pancreatic fistulas are not equivalent after proximal, distal, and central pancreatectomy. *J Gastrointest Surg.* 2006;10:1264–1278.
2. Gough BL, Levi S, Sabesan A, et al. Complex distal pancreatectomy outcomes performed at a single institution. *Surg Oncol.* 2018;27:428–432.
3. Roussel E, Clément G, Lenne X, et al. Is centralization needed for patients undergoing distal pancreatectomy? *Pancreas.* 2019;48:1188–1194.
4. Mehrabi A, Hafezi M, Arvin J, et al. A systematic review and meta-analysis of laparoscopic versus open distal pancreatectomy for benign and malignant lesions of the pancreas: it's time to randomize. *Surgery.* 2015;157:45–55.
5. Chen K, Pan Y, Huang Cj, et al. Laparoscopic versus open pancreatic resection for ductal adenocarcinoma: separate propensity score matching analyses of distal pancreatectomy and pancreaticoduodenectomy. *BMC Cancer.* 2021;21:382.
6. Korrel M, Vissers FL, van Hilst J, et al. Minimally invasive versus open distal pancreatectomy: an individual patient data meta-analysis of two randomized controlled trials. *HPB.* 2021;23:323–330.
7. Farges O, Bendersky N, Truant S, et al. The theory and practice of pancreatic surgery in France. *Ann Surg.* 2017;266:797–804.
8. Vonlanthen R, Lodge P, Barkun JS, et al. Toward a consensus on centralization in surgery. *Ann Surg.* 2018;268:712–724.
9. El Amrani M, Clement G, Lenne X, et al. Failure-to-rescue in patients undergoing pancreatectomy: is hospital volume a standard for quality improvement programs? Nationwide analysis of 12,333 patients. *Ann Surg.* 2018;268:799–807.
10. Wellner UF, Keck T. Quality indicators in pancreatic surgery: lessons learned from the German. *Visc Med.* 2017;33:126–130.
11. Talluri S. Benchmarking method for business-process reengineering and improvement. *Int J Flex Manuf Syst.* 2000;12:291–304.
12. Low DE, Kuppusamy MK, Alderson D, et al. Benchmarking complications associated with esophagectomy. *Ann Surg.* 2019;269:291–298.
13. Lim RB, Blackburn GL, Jones DB. Benchmarking best practices in weight loss surgery. *Curr Probl Surg.* 2010;47:79–174.
14. Liu JB, Schuitevoerder D, Vining CC, et al. Benchmarking perioperative outcomes of cytoreductive surgery for cancer: implications for quality measurement. *Ann Surg Oncol.* 2020;27:5039–5046.
15. Ercolani G, D'Acapito F, Solaini L, et al. Benchmarking a new tertiary referral center for hepato-biliary surgery through a critical systematic review of available literature. *Int J Surg.* 2020;84:78–84.
16. Raptis DA, Linecker M, Kambakamba P, et al. Defining benchmark outcomes for ALPPS. *Ann Surg.* 2019;270:835–841.
17. Sánchez-Velázquez P, Muller X, Malleo G, et al. Benchmarks in pancreatic surgery: a novel tool for unbiased outcome comparisons. *Ann Surg.* 2019;270:211–218.
18. Raptis DA, Sánchez-Velázquez P, Machairas N, et al. Defining benchmark outcomes for pancreaticoduodenectomy with portomesenteric venous resection. *Ann Surg.* 2020;272:731–737.
19. Gero D, Muller X, Staiger RD, et al. How to establish benchmarks for surgical outcomes? A checklist based on an International Expert Delphi Consensus. *Ann Surg.* 2022;275:115–120.
20. Hartwig W, Vollmer CM, Fingerhut A, et al. Extended pancreatectomy in pancreatic ductal adenocarcinoma: definition and consensus of the International Study Group for Pancreatic Surgery (ISGPS). *Surgery.* 2014;156:1–14.
21. El Amrani M, Clément G, Lenne X, et al. Should all pancreatic surgery be centralized regardless of patients' comorbidity? *HPB.* 2020;22:1057–1066.
22. Dindo D, Demartines N, Clavien P-A. Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. *Ann Surg.* 2004;240:205–213.
23. Bassi C, Dervenis C, Butturini G, et al. Postoperative pancreatic fistula: an International Study Group (ISGPF) definition. *Surgery.* 2005;138:8–13.
24. Wente MN, Veit JA, Bassi C, et al. Postpancreatectomy hemorrhage (PPH)—an International Study Group of Pancreatic Surgery (ISGPS) definition. *Surgery.* 2007;142:20–25.
25. Wente MN, Bassi C, Dervenis C, et al. Delayed gastric emptying (DGE) after pancreatic surgery: a suggested definition by the International Study Group of Pancreatic Surgery (ISGPS). *Surgery.* 2007;142:761–768.
26. Bashir MU, Kandilis A, Jackson NM, et al. Distal pancreatectomy outcomes: Perspectives from a community-based teaching institution. *Ann Hepato-Biliary-Pancreatic Surg.* 2020;24:156–161.
27. Tol JAMG, Gouma DJ, Bassi C, et al. Definition of a standard lymphadenectomy in surgery for pancreatic ductal adenocarcinoma: a consensus statement by the International Study Group on Pancreatic Surgery (ISGPS). *Surgery.* 2014;156:591–600.
28. Ishida H, Ogura T, Takahashi A, et al. Optimal region of lymph node dissection in distal pancreatectomy for left-sided pancreatic cancer based on tumor location. *Ann Surg Oncol.* 2022;29:2414–2424.
29. Mackay TM, Smits FJ, Roos D, et al. The risk of not receiving adjuvant chemotherapy after resection of pancreatic ductal adenocarcinoma: a nationwide analysis. *HPB.* 2020;22:233–240.
30. van Hilst J, Strating EA, de Rooij T, et al. Costs and quality of life in a randomized trial comparing minimally invasive and open distal pancreatectomy (LEOPARD trial). *Br J Surg.* 2019;106:910–921.
31. Sutton TL, Potter KC, O'Grady J, et al. Intensive care unit observation after pancreatectomy: treating the patient or the surgeon? *J Surg Oncol.* 2022;125:847–855.
32. Mueller M, Breuer E, Mizuno T, et al. Perihilar cholangiocarcinoma—novel benchmark values for surgical and oncological outcomes from 24 expert centers. *Ann Surg.* 2021;274:780–788.