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International survey on opinions and use of robot-assisted and laparoscopic minimally invasive pancreatic surgery: 5-year follow up

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Citation

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ORIGINAL ARTICLE

International survey on opinions and use of robot-assisted and laparoscopic minimally invasive pancreatic surgery: 5-year follow up

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Abstract

Background: Evidence on the value of minimally invasive pancreatic surgery (MIPS) has been increasing but it is unclear how this has influenced the view of pancreatic surgeons on MIPS.

Methods: An anonymous survey was sent to members of eight international Hepato-Pancreato-Biliary Associations. Outcomes were compared with the 2016 international survey.

Results: Overall, 315 surgeons from 47 countries participated. The median volume of pancreatic resections per center was 70 (IQR 40−120). Most surgeons considered minimally invasive distal pancreatectomy (MIDP) superior to open (ODP) (94.6%) and open pancreatoduodenectomy (OPD) superior to minimally invasive (MIPD) (67.9%). Since 2016, there has been an increase in the number of surgeons performing both MIDP (79%−85.7%, $p = 0.024$) and MIPD (29%−45.7%, $p < 0.001$), and an increase in the use of the robot-assisted approach for both MIDP (16%−45.6%, $p < 0.001$) and MIPD (23%−47.9%, $p < 0.001$). The use of laparoscopy remained stable for MIDP (91% vs. 88.1%, $p = 0.245$) and decreased for MIPD (51%−36.8%, $p = 0.024$).

Conclusion: This survey showed considerable changes of MIPS since 2016 with most surgeons considering MIDP superior to ODP and an increased use of robot-assisted MIPS. Surgeons prefer OPD and therefore the value of MIPD remains to be determined in randomized trials.

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Introduction

Minimally invasive pancreatic surgery (MIPS) has emerged to lessen the impact of surgical trauma on patients. For many years, the evidence base for MIPS over open pancreatic surgery has been limited. In 2016, the International Hepato-Pancreato-Biliary Association (IHPBA) organized a global state-of-the-art conference on MIPS.[1] As a preparation for this meeting a survey was performed questioning hepato-pancreato-biliary (HPB)-surgeons worldwide.[2] The survey revealed that HPB surgeons valued the implementation of MIPS, mostly for minimally invasive distal pancreatectomy (MIDP), while the value of minimally invasive pancreatoduodenectomy (MIPD) was unclear at that time. Lack of proper training was preventing 60% of the surgeons from performing MIPS. Ninety percent of the surgeons expressed willingness to participate in an international registry on MIPS.

The outcomes of this worldwide survey were then used to guide research endorsed by the IHPBA and E-AHPBA after the first guideline meeting, resulting in the Miami International Evidence-based Guidelines on Minimally Invasive Pancreas Resection in 2019.[3] Since then, MIPS has gained increasing popularity, with a growing body of evidence supporting its use, including several completed and ongoing randomized controlled trials and individual patient data meta-analyses.[4–8]

In September 2022, the First Internationally validated European Guidelines on Minimally Invasive Pancreatic Surgery (EGUMIPS) meeting was held in Brescia, Italy.[9] As a preparation for this meeting, a new survey was conducted, with the aim of determining the 5-year impact of recent developments on surgeons' experience, annual resection volumes and opinions towards both laparoscopic and robot-assisted MIPS.

Methods

Study population and design

Between March 2022 and October 2022, an online survey was sent using Google Docs (Google, Mountain View, CA) to all surgeon members of the International Hepato-Pancreato-Biliary Association (IHPBA), Asian-Pacific Hepato-Pancreato-Biliary Association (APHPBA), Americas Hepato-Pancreato-Biliary Association (AHPBA), European-African Hepato-Pancreato-Biliary Association (E-AHPBA), Japanese Society of Hepato-Biliary-Pancreatic Surgery (JSHPBS), Dutch Pancreatic Cancer Group (DPCG), European Consortium on Minimally Invasive Pancreatic Surgery (E-MIPS), International Consortium on Minimally Invasive Pancreatic Surgery (I-MIPS), Pancreas Club, and Society of American Gastrointestinal and Endoscopic Surgeons (SAGES). Due to an overlap in the membership databases of the associations and their confidentiality requirements, the total number of invited surgeons was unknown. The survey was sent out three times in total. Opinions of surgeons who performed laparoscopic, robotic, both or open surgery were solicited to obtain a balanced view on this topic. The participation invitation explicitly included that also the opinion of surgeons performing open pancreatic surgery was considered valuable for this survey. The survey was conducted anonymously but participants could optionally leave their contact information to receive notifications on the survey. It was not possible to fill out the survey twice or incompletely. This survey was a collaboration between the EGUMIPS Steering Committee and the IHPBA Innovation and Research Committees.

Content of the survey

The survey consisted of 66 questions. To be able to study trends over time, it included key questions from the previous survey in 2016. Additionally, questions focusing specifically on novel updates were included. The survey covered both laparoscopic and robot-assisted surgery. It included demographic information (e.g., age, working area, center volume etc.), experience with both MIDP and MIPD, attitudes towards MIDP and MIPD, patients' selection for each approach, prospects of the learning curve, effects of MIPS on healthcare costs and training in MIPS.

Definitions

MIPS was defined as laparoscopic, robot-assisted, or combined procedures in which the pancreatic resection was performed through a minimally invasive approach. Advanced minimally invasive organ resections were defined as resections beyond cholecystectomy and appendectomy.

Statistical analysis

Generated data were processed using IBM SPSS Statistics for Windows version 26.0 (IBM Corp., Orchard Road Armonk, New York, US. Categorical data were presented as proportions, continuous data were presented as means with standard deviation (SD) for normally distributed data or medians with interquartile-range (IQR) for non-normally distributed data. Subgroup analyses were performed to compare participants' characteristics, the use of MIDP and MIPD, learning curves, volumes, training, the value of MIPS and junior (surgical experience ≤5 years) and senior (surgical experience >5 years) surgeons between the survey of 2016 and the current survey. The Student's t-test, Mann Whitney U, Chi-square, or Fisher's exact tests were used as appropriate. A p-value of less than 0.05 was considered statistically significant. Outcomes are reported chronologically throughout the manuscript; 2016 results are followed by results of 2022.

Results

Participants

A total of 315 surgeons from 47 countries completed the survey. The median age of the surgeons was 48 years (SD 9) with a median surgical experience of 13 years (IQR 6–20). Two hundred and sixty surgeons (82.5%) were employed at an academic center and a majority (n = 249, 79%) was practicing in the field of HPB surgery (Table 1). The median annual number of pancreatic resections was 25 procedures (IQR 15–40) per surgeon and 70 procedures (IQR 40–120) per center. The median annual number of pancreatic resections per center increased since 2016 (50 vs 70, $p < 0.001$) whereas the median annual number per surgeon remained stable (22 vs 25, $p = 0.227$).

Minimally invasive distal pancreatectomy

The results of MIDP and its changes over time are displayed in Table 2. Compared to 2016, both the number of surgeons performing MIDP (345/435 (79%) vs 270/315 (85.7%), $p = 0.024$) and the total volume (i.e. personal experience) of MIDPs performed by individual surgeons (median 20 (IQR 10–50) vs 50 (IQR 20–100), $p < 0.001$) increased. The most common cited reason for not performing MIDP was that the procedure was being performed by another surgeon (62.2%), whereas lack of specific training (60%) was the most frequently reported reason in 2016, compared to 42.2% ($p = 0.051$) of the present survey. Among surgeons who performed MIDP, the laparoscopic approach was the most common (88.1%), followed by the robot-assisted approach (45.6%), and others (e.g. hand-assisted and combined procedures, 22.9%). The use of the robot-assisted approach increased significantly compared to 2016 (16% vs 45.6%, $p < 0.001$) while the use of laparoscopy remained stable (91% vs 88.1%, $p = 0.245$). Surgeons also reported a higher overall rate of MIDP (70% (IQR 33–95) vs 80% (IQR 50–90), $p < 0.001$). Overall, fewer contraindications were reported for MIDP in the present survey than in 2016. Involvement of other organs was the most reported contraindication but decreased in comparison to 2016 (66% vs 55.2%, $p = 0.006$). Arterial tumor involvement was similarly reported to 2016 (47% vs 50.4%, $p = 0.436$) while fewer surgeons considered large tumor size (33% vs 19.3%, p=<0.001), and pancreatic cancer (19% vs 4.4%, p = <0.001) as contraindications. Overall, a higher rate of surgeons reported no contraindications for MIDP at all (16.7% vs 11%, $p = 0.040$).

Minimally invasive pancreatoduodenectomy

The results of MIPD and its changes over time are shown in Table 3. Compared to 2016, both the number of surgeons

Table 1 Characteristics of participating surgeons

	2016 (n = 435)	2022 (n = 315)	*p*
Age, years	47 (8)[a]	48 (9)[a]	0.265
Surgical experience as an attending surgeon, years	12 (6–20)[b]	13 (6–20)[b]	0.749
Scope of surgical practise			
Hepato-Pancreato-Biliary surgery	312 (72%)	249 (79.0%)	0.023
Pancreatic surgery	128 (29%)	133 (42.2%)	<0.001
Surgical oncology	115 (26%)	96 (30.5%)	0.225
Gastrointestinal surgery	108 (25%)	57 (18.1%)	0.028
General surgery	84 (19%)	55 (17.5%)	0.520
Liver surgery	55 (13%)	46 (14.6%)	0.438
Employed at an academic center	352 (81%)	260 (82.5%)	0.572
Pancreatic resections annually performed as primary surgeon	22 (12–40)[b]	25 (15–40)[b]	0.227
Pancreatic resections annually performed in center	50 (30–100)[b]	70 (40–120)[b]	<0.001

Outcomes are displayed as numbers (proportions) unless stated otherwise.
[a] Mean (standard deviation).
[b] Median (interquartile range).

Table 2 Minimally invasive distal pancreatectomy

	2016 (n = 435)	2022 (n = 315)	*p*
Surgeons performing MIDP	345 (79%)	270 (85.7%)	0.024
Total performed MIDPs per surgeon[a]	20 (10–50)	50 (20–100)	<0.001
If not performing MIDP, reason	**N = 90**	**N = 45**	
Lack of specific training	54 (60%)	19 (42.2%)	0.051
Procedure is performed by another surgeon	37 (41%)	28 (62.2%)	0.021
Lack of time in surgical schedule	23 (26%)	5 (11.1%)	0.051
Institutional culture discourages it	14 (16%)	1 (2.2%)	0.020
Difficulty of the surgical technique	13 (14%)	3 (6.7%)	0.188
Costs are too high	13 (14%)	3 (6.7%)	0.188
Not relevant in surgeons center	12 (13%)	1 (2.2%)	0.028
Type MIDP performed	**N = 345**	**N = 270**	
Solitary laparoscopic	314 (91%)	238 (88.1%)	0.245
Solitary robot-assisted	54 (16%)	123 (45.6%)	<0.001
Hand-assisted minimally invasive	45 (13%)	22 (8.1%)	0.053
Laparoscopic mobilization, open dissection	27 (8%)	29 (10.7%)	0.212
Laparoscopic mobilization, robot-assisted dissection	11 (3%)	11 (4.1%)	0.557
DPs performed personally by a MI approach	70% (33%–95%)[a]	80% (50%–90%)[a]	0.001
Contraindications for MIDP	**N = 435**	**N = 270**	
Involvement of other organs	285 (66%)	149 (55.2%)	0.006
Arterial tumor involvement	206 (47%)	136 (50.4%)	0.436
Venous varices or thrombosis	153 (35%)	73 (27.0%)	0.024
Large tumor size	145 (33%)	52 (19.3%)	<0.001
Venous tumor involvement	144 (33%)	74 (27.4%)	0.112
Risk of intraoperative bleeding	86 (20%)	45 (16.7%)	0.303
Pancreatic cancer	83 (19%)	12 (4.4%)	<0.001
ASA score >3	79 (18%)	33 (12.2%)	0.036
History of radiotherapy in the pancreatic region	57 (13%)	20 (7.4%)	0.018
Prior laparotomy	54 (12%)	18 (6.7%)	0.014
History of chronic pancreatitis	47 (11%)	30 (11.1%)	0.899
Morbid obesity	40 (9%)	15 (5.6%)	0.080
Advanced age	18 (4%)	4 (1.5%)	0.049
Need for spleen preservation	17 (4%)	4 (1.5%)	0.065
None	49 (11%)	45 (16.7%)	0.040

Outcomes are displayed as numbers (proportions) unless stated otherwise.
Abbreviations: MIDP = minimally invasive distal pancreatectomy, DP = distal pancreatectomy, MI = minimally invasive, ASA = American score of anesthesiologists.
[a] Median (interquartile range).

performing MIPD (124/435 (29%) vs 144/315 (45.7%), $p < 0.001$) and the total volume (i.e. personal experience) of MIPDs performed by individual surgeons (median 12 (IQR 4–40) vs 25 (IQR 10–72), $p < 0.001$) increased. Lack of specific training was the most commonly cited reason for not performing MIPD (55%), as similar to 2016 (62%, $p = 0.129$). Among surgeons who performed MIPD, the robot-assisted approach was the most common (47.9%). Use of laparoscopic MIPD significantly decreased over time (51% vs 36.8%, $p = 0.024$), whereas the use of the robot-assisted approach increased (23% vs 47.9%, $p < 0.001$). The number of PDs performed via a minimally invasive approach increased from 2016 (18% (IQR 5–50) vs 25% (IQR 10–50%), $p = 0.056$). Among the 144 surgeons who performed MIPD, 131 surgeons (91%) considered arterial tumor involvement a contraindication for MIPD, significantly increasing from 2016 (83%, $p = 0.017$). Other frequently reported contraindications included involvement of other organs (67.4%) and tumor involvement of the portal/superior mesenteric vein (64.6%).

Table 3 Minimally invasive pancreatoduodenectomy

	2016 (n = 435)	2022 (n = 315)	*p*
Performing MIPD	124 (29%)	144 (45.7%)	<0.001
Total performed MIPDs per surgeon[a]	12 (4–40)[a]	25 (10–72)[a]	<0.001
If not performing MIPD, reason	**N = 311**	**N = 171**	
Lack of specific training	193 (62%)	94 (55.0%)	0.129
Difficulty of the surgical technique	136 (44%)	38 (22.2%)	<0.001
Lack of time in surgical schedule	114 (37%)	46 (26.9%)	0.030
Costs are too high	74 (24%)	24 (14.0%)	0.011
Institutional culture discourages it	71 (23%)	29 (17.0%)	0.128
Not relevant in surgeons center	55 (18%)	36 (21.1%)	0.366
No second surgeon trained in MIPS available	47 (15%)	27 (15.8%)	0.844
Procedure is performed by another surgeon	34 (11%)	47 (27.5%)	<0.001
Type MIPD performed	**N = 124**	**N = 144**	
Fully laparoscopic	63 (51%)	53 (36.8%)	0.024
Laparoscopic resection, open reconstruction	51 (41%)	51 (35.4%)	0.383
Fully robot-assisted	28 (23%)	69 (47.9%)	<0.001
Laparoscopic resection, robot-assisted reconstruction	10 (8%)	15 (10.4%)	0.498
Pancreatoduodenectomies performed MI	18% (5%–50%)[a]	25% (10%–50%)[a]	0.056
Contraindications for performing MIPD	**N = 435**	**N = 144**	
Arterial tumor involvement	359 (83%)	131 (91%)	0.017
Venous tumor involvement	285 (66%)	93 (64.6%)	0.799
Involvement of other organs	268 (62%)	97 (67.4%)	0.234
Large tumor size	158 (36%)	41 (28.5%)	0.077
Pancreatic cancer	92 (21%)	9 (6.3%)	<0.001
ASA score >3	91 (21%)	27 (18.8%)	0.537
Morbid obesity	77 (18%)	33 (22.9%)	0.188
History of radiotherapy in the pancreatic region	71 (16%)	19 (13.2%)	0.337
History of chronic pancreatitis	68 (16%)	28 (19.4%)	0.318
Prior laparotomy	58 (13%)	13 (9.0%)	0.153
Advanced age	36 (8%)	12 (8.3%)	0.949
None	28 (6%)	5 (3.5%)	0.183

Outcomes are displayed as numbers (proportions) unless stated otherwise.
Abbreviations: MIPD = minimally invasive pancreatoduodenectomy, MI = minimally invasive, MIPS = minimally invasive pancreatic surgery, ASA = American score of anesthesiologists.
[a] Median (interquartile range).

Training and credentialing

Specific training in MIPS was the most frequently mentioned essential criterion for performing both MIDP (73.3%) and MIPD (87.5%), which increased compared to 2016 (MIDP: 60%, MIPD: 74%) (Table 4). In 2016, most surgeons considered specific training in open distal pancreatectomy (ODP) and open pancreatoduodenectomy (OPD) essential. Over time, fewer surgeons considered training in ODP essential for MIDP (71% vs 55.6%, $p < 0.001$), while training in OPD continued to be considered essential for MIPD (81% vs 86.1%, $p = 0.142$).

The survey revealed that more surgeons received training in MIPS (37% vs 54%, $p < 0.001$) with robotic training being described more often. The number of procedures considered necessary to complete the learning curve increased significantly for both MIDP (from 10 procedures (IQR 10–20) to 20 (IQR 14–30), $p < 0.001$) and MIPD (from 24 procedures (IQR 15–50) to 30 (IQR 20–50), $p < 0.001$).

More surgeons reported that there should be a credentialing process for MIPS (74% vs 84.4%, $p < 0.001$), which should include training in MIPS, training in advanced minimally invasive surgery, a minimum number of cases performed under proctoring, and training in open pancreatic resection (Table 5).

Value of MIPS

Overall, 88.9% of the surgeons considered a minimally invasive approach beneficial (Table 6). Compared with 2016, more

Table 4 Essentials and training for performing minimally invasive pancreatic resections

	2016 (n = 435)	2022 (n = 315)	*p*
Essential for performing MIDP	**N = 435**	**N = 270**	
Specific ODP training	310 (71%)	150 (55.6%)	<0.001
Specific MIPS training	261 (60%)	198 (73.3%)	<0.001
High volume pancreatic center	253 (58%)	171 (63.3%)	0.173
Training MI gastrointestinal surgery	226 (52%)	157 (58.1%)	0.108
Multidisciplinary assessment of the patient	123 (28%)	96 (35.6%)	0.042
Two surgeons trained in MIPS	95 (22%)	87 (32.2%)	0.002
High volume MIPS center	76 (18%)	97 (35.9%)	<0.001
Specific MIPS accreditation	15 (3%)	25 (9.3%)	0.001
Essential for performing MIPD	**N = 435**	**N = 144**	
Specific OPD training	350 (81%)	124 (86.1%)	0.142
Specific MIPS training	322 (74%)	126 (87.5%)	<0.001
High volume pancreatic center	304 (70%)	111 (77.1%)	0.107
Specific training MI gastrointestinal surgery	243 (56%)	115 (79.9%)	<0.001
Two surgeons trained in MIPS	149 (34%)	68 (47.2%)	0.006
High volume MIPS center	127 (29%)	75 (52.1%)	<0.001
Multidisciplinary assessment of the patient	118 (27%)	53 (36.8%)	0.031
Specific MIPS accreditation	23 (5%)	22 (15.3%)	<0.001
Training	**N = 435**	**N = 315**	
Benefit from specific MIDP training	275 (63%)	207 (65.7%)	0.481
Benefit from specific MIPD training	350 (81%)	267 (84.8%)	0.128
Received training in MIPS	161 (37%)	170 (54.0%)	<0.001
Learning curve and center volumes MIDP	**N = 435**	**N = 270**	
Required number of MIDP to complete learning curve	10 (10–20)[a]>	20 (14–30)[a]	<0.001
Required minimum annual center volume MIDP	-	12 (10–20)[a]	-
Learning curve and center volumes MIPD	**N = 435**	**N = 144**	
Required number of MIPD to complete learning curve	24 (15–50)[a]	30 (20–50)[a]	<0.001
Required minimum annual center volume MIPD	-	20 (11–25)[a]	-

Outcomes are displayed as numbers (proportions) unless stated otherwise. Abbreviations: MIDP = minimally invasive distal pancreatectomy, ODP = open distal pancreatectomy, OPD = open pancreatoduodenectomy, MIPS = minimally invasive pancreatic surgery, MI = minimally invasive, MIPD = minimally invasive pancreatoduodenectomy.
[a] Median (interquartile range).

surgeons believed that patients could benefit from a minimally invasive approach in both DP and PD (42% vs 66.4%, $p < 0.001$) rather than solely in DP (58% vs 30.4%, $p < 0.001$). Most surgeons considered the laparoscopic approach superior in DP (52.7%, Fig. 1), mainly because of the faster set-up time and lower costs, while the robot-assisted approach was considered superior in spleen-preserving DP (50.6%), as shown in Fig. 2. Surgeons also expected that the robot-assisted approach would provide superior value in DP in the future (57.5%). In PD, surgeons found open surgery superior (67.9%, Fig. 3), specifically in procedures involving portal vein/superior mesenteric vein resection (84.3%) and arterial resection (90.0%), as shown in Fig. 4. Half of the responding surgeons (50.2%) expected that the robot-assisted approach would have a superior value in PD in the future.

Junior and senior surgeons

The percentage of junior surgeons who received training in MIPS remained stable over time (54.6% vs 57.5%, $p = 0.687$), while the percentage of senior surgeons receiving training increased (31.7% vs 52.9%, $p < 0.001$). In 2016, 70.3% of the junior surgeons and 75.4% of the senior surgeons considered a credential process essential to perform MIPS. In 2022, these percentages increased to 84.9% ($p = 0.025$) and 84.3% ($p = 0.010$), respectively. Compared to 2016, training in MIPS, training in advanced MI surgery, and a minimum number of cases done under proctorship, were more often considered essential elements for credentialing by both junior (52.5 vs 79.5%, $p < 0.001$, 44.6% vs 61.6%, $p = 0.026$, 39.6% vs 63.0%, $p = 0.002$, respectively) and senior surgeons (53.3 vs 71.1%, $p < 0.001$, 47.3% vs 60.7%, $p = 0.001$, 42.2% vs 59.5%, $p < 0.001$, respectively).

Table 5 Credentialing

	2016 (n = 435)	2022 (n = 315)	p
There should be a credentialing process for MIPS	323 (74%)	266 (84.4%)	<0.001
If yes, for which procedure?	**N = 323**	**N = 266**	
Distal pancreatectomy and pancreatoduodenectomy	219 (68%)	187 (70.3%)	0.455
Only distal pancreatectomy	13 (4%)	6 (2.3%)	0.455
Only pancreatoduodenectomy	91 (28%)	73 (27.4%)	0.455
If yes, what are essential contents?	**N = 323**	**N = 266**	
Training in open pancreatic resection	246 (76%)	189 (71.1%)	0.160
Training in MIPS	231 (72%)	230 (86.5%)	<0.001
Training in advanced MI surgery	203 (63%)	192 (72.2%)	0.016
Minimum number of cases done under proctoring	181 (56%)	190 (71.4%)	<0.001
Video review of operations	157 (49%)	157 (59.0%)	0.012
Reporting outcomes	179 (56%)	175 (65.8%)	0.011
Participation in a registry	146 (45%)	166 (62.4%)	<0.001

Outcomes are displayed as numbers (proportions) unless stated otherwise. Abbreviations: MIPS = minimally invasive pancreatic surgery, MI = minimally invasive.

Between 2016 and 2022, the performance of MIDPs among junior surgeons remained stable (76.2% vs 74.0%, $p = 0.732$), while a trend was observed toward an increase in the performance of MIPDs (23.8% vs 37.0%, $p = 0.059$), without reaching significance. Senior surgeons performed significantly more MIDPs (80.2% vs 89.3%, $p = 0.004$) and MIPDs (29.9% vs 48.3%, $p < 0.001$).

Discussion

This international survey provides valuable insight into the trends and attitudes of HPB surgeons towards MIPS. The number of surgeons performing MIDP and MIPD has increased since 2016, along with the total volume of MIPS procedures performed by individual surgeons. The robot-assisted approach has gained popularity, especially in MIPD, whereas the use of laparoscopic PD decreased over time. Still, the open approach is considered superior in PD. In contrast, surgeons consider MIDP generally superior to open distal pancreatectomy with a preference for laparoscopy except for spleen preserving DP, where they prefer the robot-assisted approach. In the future, surgeons expect the robot-assisted approach to be superior in both PD and DP. More surgeons received training in MIPS over time. Compared to 2016, surgeons estimate the learning curve for MIDP and MIPD to be significantly longer.

After five years of technological development and implementation, this international survey is the first to follow the group's previous review performed in 2016. This survey

Table 6 Value MIPS

	2016 (n = 435)	2022 (n = 315)	p
There is an overall patient benefit of MIPS	390 (90%)	280 (88.9%)	0.737
If benefit, for which procedure	**N = 390**	**N = 280**	
Only distal pancreatectomy	224 (58%)	85 (30.4%)	<0.001
Distal pancreatectomy and pancreatoduodenectomy	165 (42%)	186 (66.4%)	<0.001
Only pancreatoduodenectomy	1 (0%)	9 (3.2%)	<0.001
	2022 (n = 315)		
Benefits MIPS outweigh the costs compared to OPR	250 (79.4%)		
Benefits RDP outweigh the costs compared to LDP/ODP	183 (58.1%)		
Benefits RPD outweigh the costs compared to LPD/OPD	205 (65.1%)		

Outcomes are displayed as numbers (proportions) unless stated otherwise. Abbreviations: MIPR = minimally invasive pancreatic resection, OPR = open pancreatic resections, RDP = robot-assisted distal pancreatectomy, LDP = laparoscopic distal pancreatectomy, ODP = open distal pancreatectomy, RPD = robot-assisted pancreatoduodenectomy, LPD = laparoscopic pancreatoduodenectomy, OPD = open pancreatoduodenectomy.

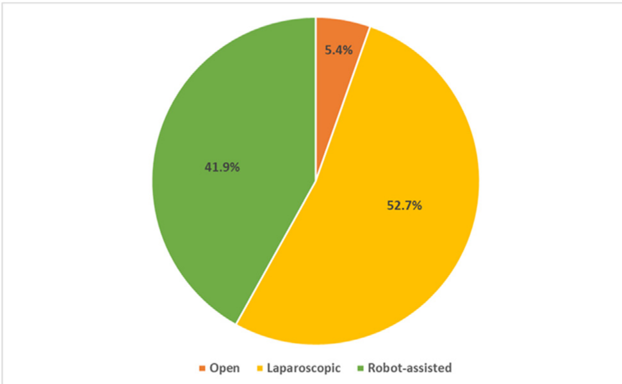

Figure 1 Which approach is currently in general superior in distal pancreactomy

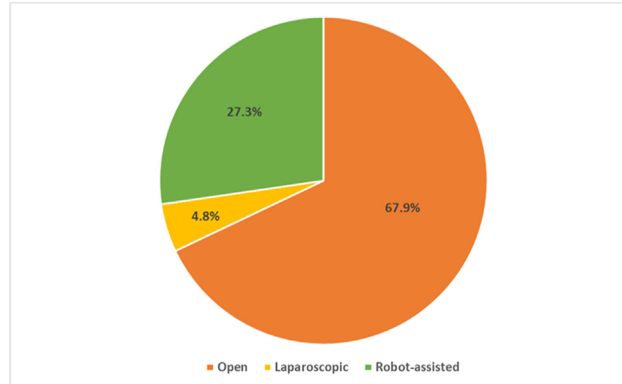

Figure 3 Which approach is currently in general superior in pancreatoduodenectomy

highlights the changing attitudes of surgeons towards the benefit of a minimally invasive approach. Where in 2016 surgeons were more reluctant and cautious towards MIPS, primarily due to the novelty and lack of training, results of this survey show that surgeons are gaining experience and are becoming more comfortable with MIPS.

Since the 2016 survey, a pan-European quality registry was founded by the European Consortium on Minimally Invasive Pancreatic Surgery (E-MIPS)[10] and several training programs for robot-assisted and laparoscopic MIPS were completed.[11–15] While at first, these training programs were focused on a single center or a single country, now also an international European training program for MIPD is ongoing (LEARNBOT NL8898). This may have contributed to the increased number of surgeons who received training and the growing use of MIPS. Consequently, more surgeons in the current survey deemed a credentialing process with training in MIPS necessary to perform MIPS, although not by 100% of the respondents. This could reflect the variability among surgical teams regarding their opinions towards the use and implementation of MIPS. The increased training opportunities may also have resulted in a lower number of contraindications reported as compared to 2016. Although additional organ or arterial tumor involvement remained an often-mentioned contraindication, pancreatic cancer or large tumor sizes were less considered a limitation for MIPS, leading to an increase in pancreatic resections performed through a minimally invasive approach. In addition, there is a growing body of literature and an expansion of retrospective studies into randomized trials focusing on oncologic outcomes in MIPS, such as the DIPLOMA cohort study[16] and DIPLOMA randomized trial,[8] confirming a broadened patient selection.

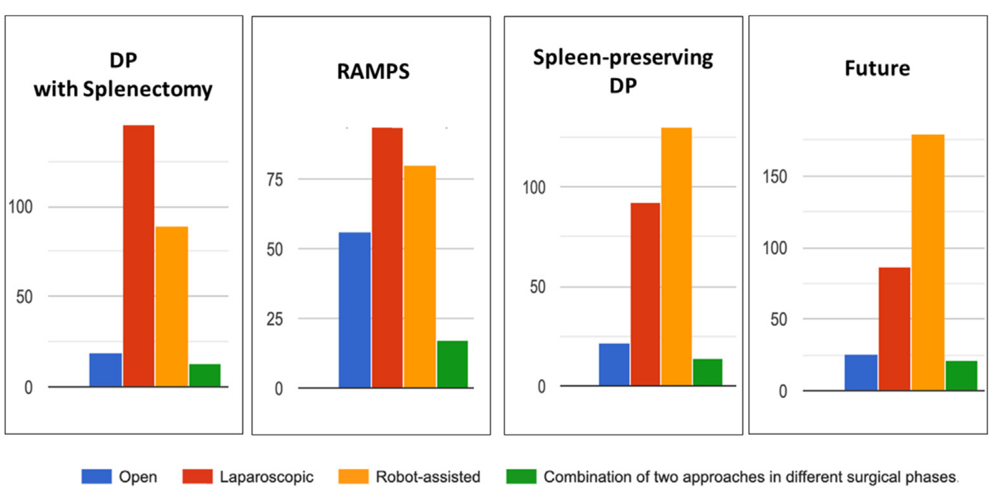

Figure 2 Preferable approaches in different DP procedures. DP = distal pancreatectomy, RAMPS= Radical antegrade modular pancreatosplenectomy. Left to right (1–4):1. Open = 7.1%, Laparoscopic = 54.9%, Robot = 33.2%, Combination = 4.8% 2. Open = 22.7%, Laparoscopic = 38.1%, Robot = 32.4%, Combination = 6.8% 3. Open = 8.5%, Laparoscopic = 35.5%, Robot = 50.6%, Combination = 5.4% 4. Open = 8.3%, Laparoscopic = 27.6% Robot = 57.5% Combination = 6.6%

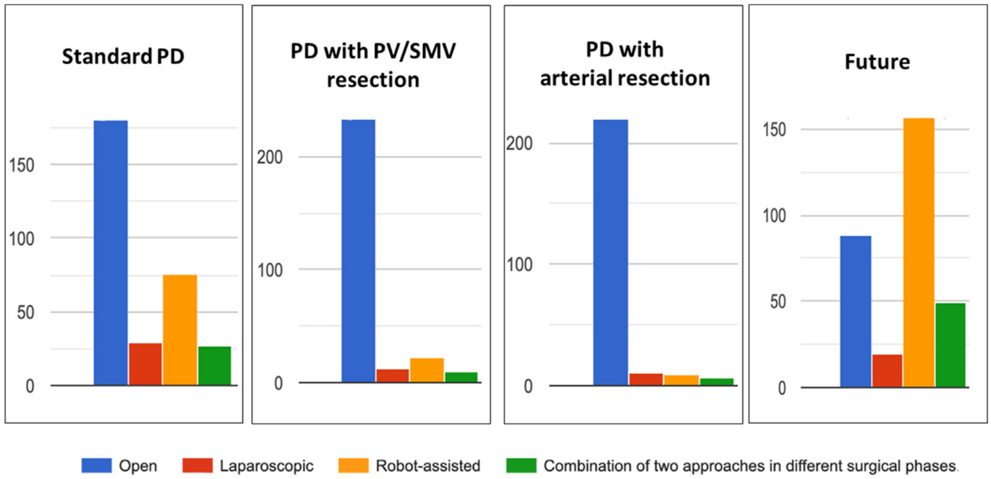

Figure 4 Preferable approaches in different PD procedures. PD = pancreatoduodenectomy, PV = portal vein, SMV = superior mesenteric vein. Left to right (1–4): 1. Open = 58.1%, Laparoscopic = 9.2%, Robot = 24.1%, Combination = 8.6% 2. Open = 84.3%, Laparoscopic = 4.3%, Robot = 7.8%, Combination = 3.6% 3. Open = 90.0%, Laparoscopic = 4.0%, Robot = 3.6%, Combination = 2.4% 4. Open = 27.9%, Laparoscopic = 6.3%, Robot = 50.2%, Combination = 15.6

Interestingly, surgeons appraised the learning curve to be longer in MIDP and MIPD than initially estimated in 2016. This result is presumably related to increased surgeons' experience and herewith knowledge of the technical difficulties. Surgical literature supports this surgeon's perception, identifying the number of procedures required for MIPS learning curves to be completed between 15 and 25 procedures in MIDP and 25–80 in MIPD.[17,18]

Ongoing research is investigating the outcomes of laparoscopic and robot-assisted pancreatic resections, with several studies suggesting that the robot-assisted approach is beneficial in more technically challenging procedures, such as in spleen preserving-DP and PD.[19,20] Accordingly, most surgeons participating in this survey used laparoscopy in DP with splenectomy or in a RAMPS procedure, but considered the robot-assisted approach superior in a spleen-preserving DP.

Similarly, as for MIPD, the present survey reported a significant decrease in the use of laparoscopic PD coupled with a two-fold increase in robot-assisted PD. It remains unclear from this data whether there has been a shift from surgeons performing laparoscopic to robot-assisted PD or whether surgeons stopped performing MIPD and others started with robot-assisted PD. Nevertheless, the decrease in the use of laparoscopic PD could be explained by the concerning outcomes of the LEOPARD-2 trial which showed a trend towards higher mortality after laparoscopic PD compared to OPD without a clear benefit of the laparoscopic approach.[5] On the other hand, three randomized trials have reported positive outcomes after laparoscopic PD including shorter hospital stay and a lower complication rate.[21–23]

Since 2016, the popularity and experience with robot-assisted PD increased, partly due to the development of national and international training programs. Improved intra –and post-operative outcomes were reported after structured robot-assisted PD training programs.[13,24] Moreover, early literature series of robot-assisted PD have reported non-inferior or equivalent outcomes to OPD in terms of postoperative outcomes.[25,26]

The outcomes of the present survey should be interpreted with several limitations in mind. First, the outcomes remain opinion based and could have been severely influenced by the type of surgeons that responded. Although the nature of the survey was to include surgeons with all types of pancreatic surgery experience, it remains impossible to control who will respond. Surgeons more passionate about MIPS may therefore have been more likely to respond, which may have affected the survey results. However, the surgical practice of participating surgeons consisted of more pancreatic surgery and fewer surgical procedures outside HPB compared to 2016, making the results of this survey more representative. Second, fewer survey responses were obtained compared to 2016, especially from North America. We think this could, to some extent, be explained by survey tiredness since in recent years an increasing number of surveys is being circulated. Nevertheless, the main strength of this survey is the large domain and the wide representation of members of eight international associations for HPB surgery.

Conclusion

This international survey on MIPS demonstrated the increased implementation and use of MIPS, which have critical implication for the training, credentialing and adoption of these procedures. Considerable changes were observed in the attitudes and trends towards MIPS since 2016, with most surgeons considering MIDP superior to ODP and an increased use of robot-assisted MIPS. Surgeons still prefer OPD and therefore the value of MIPD remains to be determined in randomized trials.

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Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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