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ORIGINAL ARTICLE

Defining the practice of pancreatoduodenectomy around the world

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Abstract

Background: Pancreatoduodenectomy (PD) is a technically challenging operation characterized by numerous management decisions.

Objective: This study was designed to test the hypothesis that there is significant variation in the contemporary global practice of PD.

Methods: A survey with native-language translation was distributed to members of 22 international gastrointestinal surgical societies. Practice patterns and surgical decision making for PD were assessed. Regions were categorized as North America, South/Central America, Asia/Australia, and Europe/Africa/Middle East.

Results: Surveys were completed by 897 surgeons, representing six continents and eight languages. The median age and length of experience of respondents were 45 years and 13 years, respectively. In 2013, surgeons performed a median of 12 PDs and reported a median career total of 80 PDs; only 53.8% of respondents had surpassed the number of PDs considered necessary to surmount the learning curve (>60). Significant regional differences were observed in annual and career PD volumes ($P < 0.001$). Only 3.7% of respondents practised pancreas surgery exclusively, but 54.8% performed only hepatopancreatobiliary surgery. Worldwide, the preferred form of anastomotic reconstruction was pancreatojejunostomy (88.7%). Regional variability was evident in terms of anastomotic/suture technique, stent use and drain use (including type and number), as well as in the use of octreotide, sealants and autologous patches ($P < 0.02$ for all).

Conclusions: Globally, there is significant variability in the practice of PD. Many of these choices contrast with established randomized evidence and may contribute to variance in outcomes.

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Introduction

Pancreatoduodenectomy (PD) is a technically challenging operation characterized by numerous management decisions. Operative options refer to the type of anastomotic reconstruction, as well as the use of trans-anastomotic stents, biological sealants, autologous tissue patches and drains. Additionally, surgeons are confronted with management choices concerning the administration of prophylactic somatostatin analogues and the duration of drainage. Many of these practices have been scrutinized in randomized controlled trials (RCTs), which have established Level I evidence in the contemporary surgical literature.[1–6]

The International Study Group on Pancreatic Surgery (ISGPS) has served as the foundation for many of these investigations. Through a rigorous consensus process, the ISGPS established standardized definitions for many post-pancreatectomy complications.[7–9] In addition to improving the quality of comparative research, these definitions have facilitated unbiased comparisons of intraoperative techniques and management decisions.

This study explores the hypothesis that there is significant variation in the contemporary global practice of PD. The primary aims of this study are two-fold. The first is to establish global benchmarks for the surgical experience of surgeons who

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practise PD; results will be compared with published cut-offs relating to the PD learning curve and high-volume status. The second aim is to report current worldwide practice patterns in surgeons who perform PD. Collective responses will be compared with best clinical practice established by contemporary Level I evidence. Trends will be assessed to determine if there is regional bias in the implementation of best clinical practices.

Materials and methods

This study was approved by the institutional review board (IRB) at the Hospital of the University of Pennsylvania. A structured, web-based survey was designed and administered to surgeons who perform pancreatic surgery through 22 international gastrointestinal surgical societies. First, support was engendered from several of the larger international gastrointestinal surgical societies, including the International Hepato-Pancreato-Biliary Association (IHPBA), the Society for Surgery of the Alimentary Tract (SSAT) and the Pancreas Club. These organizations distributed the survey to their extensive global memberships. Next, major regional associations [the Americas Hepato-Pancreato-Biliary Association (AHPBA), the Asian-Pacific Hepato-Pancreato-Biliary Association (A-PHPBA), the European/African/Middle Eastern Hepato-Pancreato-Biliary Association (E-AHPBA)] were targeted, as were many of the national chapters under their respective purviews. To facilitate global catchment, the e-surveys were made available in eight different languages, including English, Chinese (i.e. Mandarin), French, German, Italian, Japanese, Portuguese and Spanish. Although the precise number of surgeons to whom the survey was offered was not evident (some memberships overlapped across the various participating organizations), it is estimated that this totalled 1500–2000 surgeons globally.

Surgeons initially indicated their region of practice. Geographical boundaries were established *a priori* as follows: North America; South and Central America; Asia and Australia, and Europe, Africa and the Middle East. Next, respondents were asked to report any relevant fellowship training, as well as other experience-related parameters, such as age, annual and career volumes, and years of experience as an attending or staff surgeon. The scope of the respondent's current clinical practice was also characterized.

Questions regarding the practice patterns of individual surgeons were presented using a modified Likert scale: (i) never, 0%; (ii) occasionally, 1–25%; (iii) sometimes, 26–75%; (iv) frequently, 76–99%, and (v) always, 100%. Specific operative techniques evaluated were pancreatogastrostomy (PG), dunking/invagination, isolated Roux limb, duct occlusion, anastomotic suturing preferences, trans-anastomotic stents, autologous tissue patches, biological sealants (e.g. Tisseel, fibrin glue), and placement of externalized drains. Management decisions referred to the administration of prophylactic somatostatin analogues (e.g. octreotide), and whether the surgeons practise early drain removal [postoperative day (PoD) ≤3] based upon drain amylase values.

Statistical analysis

Descriptive statistics are presented as frequencies for categorical variables, and as the mean ± standard deviation (SD) and median [interquartile range (IQR)] for continuous variables. Pearson's chi-squared test or Fisher's exact test, and independent Student's *t*-tests or analysis of variance (ANOVA) testing were used to analyse categorical and continuous variables, respectively. Non-parametric comparisons of continuous variables were assessed by Wilcoxon rank sum tests or Kruskal–Wallis one-way ANOVA. *P*-values of ≤0.05 were considered to indicate statistical significance. All tests were two-sided. Statistical computations were performed utilizing IBM SPSS Statistics for Windows Version 22.0 (IBM Corp., Armonk, NY, USA).

Results

Demographics and surgical experience

Surveys were completed by 897 surgeons, representing six continents and eight languages. Data fields were completed 98.9% of the time. There were significant differences in the demographic profile and experience of surgeons between regions (Table 1). A total of 54.8% of surgeons described the scope of their clinical practice as hepatopancreatobiliary (HPB) surgery, whereas just 3.6% said they practised pancreas surgery exclusively. Asian/Australian surgeons were significantly more likely to have an HPB-only practice compared with those in other regions ($P < 0.001$). The median age and years of experience as an attending surgeon were 45 years (IQR: 39–54 years) and 13 years (IQR: 6–22 years), respectively. Within the last year, surgeons had performed a median of 12 PDs (IQR: 6–25 PDs). Their median cumulative career volume amounted to 80 PDs (IQR: 30–200 PDs); consequently, only 35.5% of responding surgeons were considered to have a high-volume PD practice (i.e. ≥20 PDs per year).[10] This designation was most common in North America (50.0%), and least common in South/Central America (8.0%). Interestingly, only 53.8% of all surgeons had surpassed the learning curve for open PD, which has been reported to peak at 60 PDs.[11] Nearly two-thirds of North American surgeons had exceeded this threshold, compared with fewer than a quarter of South American/Mexican surgeons ($P < 0.001$).

Operative approaches

Around a third of surgeons across the world use the same pancreatoenteric reconstruction in every case. Pancreatojejunostomy (PJ) was the preferred anastomotic technique (88.7%) (Table 2) and was favoured by 96.4% of North American surgeons. Conversely, PG was selected by less than one-tenth of all respondents: European/African/Middle Eastern surgeons demonstrated the greatest proclivity for this technique (16.5%; $P < 0.001$). Isolated Roux limb reconstruction was uncommon

Table 1 Demographics and experience of hepatopancreatobiliary (HPB) surgeons (n = 891*) by region

Variable	Asia/Australia	Europe/Africa/Middle East	North America	South/Central America	Overall	*P*-value
Surgeons, *n* (%)	209 (23.5%)	273 (30.6%)	282 (31.6%)	127 (14.3%)	891	–
Non-English survey response, *n* (%)	15 (7.2%)	32 (11.7%)	0	86 (67.7%)	133 (14.9%)	<0.001
Fellowship training, *n* (%)	183 (87.6%)	203 (74.9%)	247 (88.2%)	113 (89.0%)	746 (84.1%)	<0.001
Scope of clinical practice, *n* (%)						
Pancreas only	5 (2.4%)	9 (3.3%)	14 (5.0%)	4 (3.1%)	32 (3.6%)	<0.001
HPB	144 (69.2%)	166 (60.8%)	142 (50.4%)	36 (28.3%)	488 (54.8%)	
Surgical oncology	15 (7.2%)	48 (17.6%)	76 (27.0%)	56 (44.1%)	195 (21.9%)	
General surgery	31 (14.9%)	43 (15.8%)	42 (14.9%)	29 (22.8%)	145 (16.3%)	
Other	13 (6.3%)	7 (2.6%)	8 (2.8%)	2 (1.6%)	30 (3.4%)	
Age, years						
Mean (SD)	47.0 (9.1)	47.0 (9.7)	48.0 (10.9)	43.9 (9.8)	46.9 (10.1)	0.002
Median (IQR)	46 (40–54)	46 (39–54)	47 (40–55)	42 (36–49)	45.0 (39–54)	0.001
Years of experience						
Mean (SD)	15.5 (10.2)	14.4 (10.3)	13.9 (11.4)	14.5 (10.1)	14.6 (10.6)	0.404
Median (IQR)	15 (7–23)	14 (6–20)	11 (4–22)	13 (6–20)	13.0 (6–22)	0.118
PD volume						
2013 calendar year						
Mean (SD)	16.1 (16.4)	18.3 (16.7)	24.2 (22.4)	8.5 (8.2)	18.2 (l8.4)	<0.001
Median (IQR)	12 (6–20)	15 (7–25)	19 (10–33)	6 (4–10)	12 (6–25)	<0.001
Annual volume designation						
≥20 (high-volume surgeon)	62 (30.0%)	101 (38.0%)	136 (50.0%)	10 (8.0%)	309 (35.5%)	<0.001
Career total number of PDs						
Mean (SD)	151.4 (220.5)	135.1 (165.9)	218 (277.7)	58.2 (80.4)	154.3 (218.0)	<0.001
Median (IQR)	71 (35–200)	92.5 (31.5–200)	133 (36.25–300)	30 (17.25–61)	80 (30–200)	<0.001
Surpassed the number of PDs required to surmount the learning curve, *n* (%)						
≥50	139 (67.1%)	179 (67.3%)	194 (70.3%)	46 (36.5%)	558 (63.8%)	<0.001
>60	110 (53.1%)	152 (57.1%)	178 (64.5%)	31 (24.6%)	471 (53.8%)	<0.001

IQR, interquartile range; SD, standard deviation.
*Six surgeons did not indicate their region.

in most regions, yet nearly a fifth of South American/Mexican surgeons (16.8%) reported always using this approach. There were also considerable degrees of variability between regions in the suture types preferred for both inner and outer layers of pancreatic anastomotic construction ($P < 0.001$ for each).

Surgeons were also asked a variety of questions regarding the placement of trans-anastomotic stents (Table 3). Globally, 26.5% of surgeons never use stents, 57.4% use them selectively, and 16.2% always employ them. Asian/Australian surgeons use them most liberally. Stents of the external variety are always employed by 2.1% of surgeons internationally; however, even when avoiding absolutes, they are selected by only 17.5% of surgeons. Short, internalized stents are used at least four times as frequently as external stents across each region.

Other techniques used to putatively maintain the integrity of the anastomosis include biological sealants and autologous tissue patches. Globally, 34.9% of respondents turn to biological sealants to augment the anastomotic connection. Similarly, over a third (38.3%) use autologous tissue patches for reinforcement. The selective use of both strategies is most common in North America.

Routine intraperitoneal drainage was reported by 59.2% of surgeons, and this practice was most common in South/Central America (71.2%). Across the world, only 26.9% of surgeons drain selectively; North American and Asian/Australian surgeons demonstrated the greatest propensity for this approach. In addition, significant variation exists around the world regarding the types and numbers of drains used. Jackson–Pratt

Table 2 Utilization of operative strategies for pancreatoenteric reconstruction, stratified by region

Variable	Asia/Australia	Europe/Africa/ Middle East	North America	South/Central America	Overall	*P*-value
Surgeons, *n* (%)	209 (23.5%)	273 (30.6%)	282 (31.6%)	127 (14.3)	891[#]	–
Preferred anastomotic reconstruction						
Pancreatojejunostomy	185 (88.5%)	221 (81.0%)	268 (96.4%)	111 (88.8%)	785 (88.7%)	<0.001[a]
End-to-side duct-to-mucosa	133 (63.6%)	169 (61.9%)	220 (79.1%)	76 (60.8%)	598 (67.6%)	
End-to-side invagination/ dunking	32 (15.3%)	35 (12.8%)	29 (10.4%)	10 (8.0%)	106 (12.0%)	
End-to-end invagination/dunking	15 (7.2%)	7 (2.6%)	17 (6.1%)	20 (16.0%)	59 (6.7%)	
End-to-end binding	5 (2.4%)	10 (3.7%)	2 (0.7%)	5 (4.0%)	22 (2.5%)	
Pancreatogastrostomy	21 (10.0%)	45 (16.5%)	9 (3.2%)	11 (8.8%)	86 (9.7%)	
Duct-to-mucosa	7 (3.3%)	7 (2.6%)	2 (0.7%)	5 (4.0%)	21 (2.4%)	
Invagination/dunking	14 (6.7%)	38 (13.9%)	7 (2.5%)	6 (4.8%)	65 (7.3%)	
No reconstruction (ductal occlusion)	0	2 (0.7%)	1 (0.4%)	0	3 (0.3%)	
Other	3 (1.4%)	5 (1.8%)	0	3 (2.4%)	11 (1.2%)	
Same type of pancreatoenteric reconstruction on every case						
No – variable according to the circumstance of the case	66 (31.6%)	110 (40.4%)	87 (31.3%)	53 (42.1%)	316 (35.7%)	0.032
Yes – same technique every time	143 (68.4%)	162 (59.6%)	191 (68.7%)	73 (57.9%)	569 (64.3%)	
Suture technique						
Single layer	48 (23.1%)	104 (38.1%)	30 (10.8%)	36 (28.6%)	218 (24.6%)	<0.001
Double layer	160 (76.9%)	169 (61.9%)	249 (89.2%)	90 (71.4%)	668 (75.4%)	
Suture type – if inner layer (duct-to-mucosa)						
Absorbable monofilament (e.g. PDS, Maxon, Monocryl)	154 (75.5%)	176 (68.5%)	221 (79.5%)	75 (59.5%)	626 (72.4%)	<0.001
Absorbable braided (e.g. vicryl)	16 (7.8%)	13 (5.1%)	28 (10.1%)	16 (12.7%)	73 (8.4%)	
Non-absorbable braided (e.g. silk, polyester)	8 (3.9%)	24 (9.3%)	5 (1.8%)	8 (6.3%)	45 (5.2%)	
Other (e.g. catgut, chromic)	6 (2.9%)	5 (1.9%)	12 (4.3%)	15 (11.9%)	38 (4.4%)	
Do not perform an inner layer	20 (9.8%)	39 (15.2%)	12 (4.3%)	12 (9.5%)	83 (9.6%)	
Suture type – if outer layer (pancreatic capsule-to-bowel)						
Absorbable monofilament (e.g. PDS, Maxon, Monocryl)	97 (46.9%)	136 (50.6%)	47 (17.0%)	40 (31.5%)	320 (36.4%)	<0.001
Absorbable braided (e.g. vicryl)	14 (6.8%)	24 (8.9%)	33 (12.0%)	27 (21.3%)	98 (11.1%)	
Non-absorbable braided (e.g. silk, polyester)	69 (33.3%)	80 (29.7%)	178 (64.5%)	31 (24.4%)	358 (40.7%)	
Other (e.g. catgut, chromic)	21 (10.1%)	10 (3.7%)	13 (4.7%)	27 (21.3%)	71 (8.1%)	
I do not perform an outer layer	6 (2.9%)	19 (7.1%)	5 (1.8%)	2 (1.6%)	32 (3.6%)	
Pancreatogastrostomy						
Never	128 (61.8%)	150 (56.2%)	185 (66.5%)	88 (69.8%)	551 (62.8%)	0.001
Occasionally (1–25%)	52 (25.1%)	65 (24.3%)	77 (27.7%)	28 (22.2%)	222 (25.3%)	
Sometimes (26–75%)	9 (4.3%)	14 (5.2%)	8 (2.9%)	2 (1.6%)	33 (3.8%)	
Frequently (76–99%)	12 (5.8%)	22 (8.2%)	4 (1.4%)	3 (2.4%)	41 (4.7%)	
Always	6 (2.9%)	16 (6.0%)	4 (1.4%)	5 (4.0%)	31 (3.5%)	

Table 2 Continued

Variable	Asia/Australia	Europe/Africa/ Middle East	North America	South/Central America	Overall	*P*-value
Dunking or invagination						
Never	86 (41.7%)	107 (39.9%)	94 (33.9%)	40 (32.5%)	327 (37.4%)	0.034
Occasionally (1–25%)	55 (26.7%)	80 (29.9%)	117 (42.2%)	41 (33.3%)	293 (33.5%)	
Sometimes (26–75%)	10 (4.9%)	8 (3.0%)	14 (5.1%)	8 (6.5%)	40 (4.6%)	
Frequently (76–99%)	32 (15.5%)	42 (15.7%)	27 (9.7%)	21 (17.1%)	122 (14.0%)	
Always	23 (11.2%)	31 (11.6%)	25 (9.0%)	13 (10.6%)	92 (10.5%)	
Duct occlusion						
Never	192 (93.7%)	231 (88.5%)	255 (92.7%)	113 (91.9%)	791 (91.6%)	0.068
Occasionally (1–25%)	8 (3.9%)	26 (10.0%)	20 (7.3%)	6 (4.9%)	60 (6.9%)	
Sometimes (26–75%)	3 (1.5%)	1 (0.4%)	0	3 (2.4%)	7 (0.8%)	
Frequently (76–99%)	1 (0.5%)	2 (0.8%)	0	0	3 (0.3%)	
Always	1 (0.5%)	1 (0.4%)	0	1 (0.8%)	3 (0.3%)	
Isolated Roux limb						
Never	152 (74.5%)	166 (62.6%)	227 (81.7%)	49 (39.2%)	594 (68.1%)	<0.001
Occasionally (1–25%)	31 (15.2%)	57 (21.5%)	37 (13.3%)	31 (24.8%)	156 (17.9%)	
Sometimes (26–75%)	4 (2.0%)	10 (3.8%)	3 (1.1%)	7 (5.6%)	24 (2.8%)	
Frequently (76–99%)	9 (4.4%)	9 (3.4%)	6 (2.2%)	17 (13.6%)	41 (4.7%)	
Always	8 (3.9%)	23 (8.7%)	5 (1.8%)	21 (16.8%)	57 (6.5%)	

[a] $P < 0.001$ even when comparing the condensed categorization of pancreatojejunostomy, pancreatogastrostomy, no reconstruction, and other.
[#] Six surgeons did not indicate their region

drains are most common in North America (57.8%), whereas Blake (51.8%) and Penrose (18.8%) drains are preferred in South/Central America ($P < 0.001$). Of those surgeons who do place drains, 60.7% place two. North Americans appeared to take the least conservative approach and reported using a single drain in 43.5% of patients. By contrast, only 19.6% of Asian/Australian surgeons place a single drain.

Management decisions

In terms of management decisions, prophylactic somatostatin analogues are never administered by 40.5% of the world's pancreatic surgeons and are always applied by just 13.6%. Surgeons from Asia/Australia and Europe/Africa/Middle East favour this practice, the use of which is more infrequent in the Americas. Another management approach involves early drain removal (PoD ≤3) based upon drain amylase values. Early drain removal is practised by 45.4% of surgeons who place drains. North America is the only region in which fewer than half of surgeons reported the use of this management strategy (31.6%; $P < 0.001$). Globally, the median preferred PoD for drain removal is PoD 5 (IQR: PoD 4–7).

Discussion

There appears to be significant heterogeneity in the demographics and practice patterns of PD surgeons around the world. Globally, it is estimated that only around half of surgeons who perform PD have carried out at least the number of PDs considered to facilitate completion of the full learning curve for this procedure (>60 PDs),[11] and, depending upon the region, this figure may be as low as 25%. Furthermore, many contemporary operative and management options differ substantially from those of evidence-based practice. Surgeons rarely utilize the PG anastomotic technique and external trans-anastomotic stents, and over two-thirds of surgeons in North America do not practise early drain removal. Other notable trends include the widespread use of techniques such as those involving the use of biological sealants and autologous tissue patches that have not been substantiated by any Level I evidence.

Tseng and colleagues performed a study in which they established the first representation of the learning curve for PD.[11] They reported that, after 60 cases, surgeons achieved significant decreases in blood loss, operative time, and duration of hospital stay; additionally, the meeting of this threshold resulted in more margin-negative resections. Applying this cut-off to the current study showed that 53.8% of the overall cohort has surpassed the PD learning curve; therefore, according to this measure, nearly half of the world's surgeons may be performing PD with suboptimal intra- and postoperative outcomes.

The most recent work to establish and evaluate the impact of annual volume and the PD learning curve was conducted by Schmidt *et al.*[10] Their study showed that high-volume surgeons (≥20 PDs per year) had reduced operative time and intraoperative blood loss, and also resected a significantly greater number

Table 3 Utilization of purported fistula mitigation strategies, stratified by region

Variable	Asia/Australia	Europe/Africa/ Middle East	North America	South/Central America	Overall	*P*-value
Surgeons, *n* (%)	209 (23.5%)	273 (30.6%)	282 (31.6%)	127 (14.3%)	891	–
Trans-anastomotic stents						
Never	37 (18.0%)	82 (30.1%)	73 (26.2%)	42 (33.1%)	234 (26.5%)	<0.001
Occasionally (1–25%)	39 (18.9%)	74 (27.2%)	73 (26.2%)	41 (32.3%)	227 (25.7%)	
Sometimes (26–75%)	23 (11.2%)	38 (14.0%)	32 (11.5%)	12 (9.4%)	105 (11.9%)	
Frequently (76–99%)	40 (19.4%)	48 (17.6%)	67 (24.0%)	20 (15.7%)	175 (19.8%)	
Always	67 (32.5%)	30 (11.0%)	34 (12.2%)	12 (9.4%)	143 (16.2%)	
Type of stent used						
Internal	112 (67.5%)	135 (71.8%)	156 (75.7%)	56 (65.9%)	459 (71.2%)	0.064
External	34 (20.5%)	42 (22.3%)	27 (13.1%)	17 (20.0%)	120 (18.6%)	
Depends on the case	20 (12.0%)	11 (5.9%)	23 (11.2%)	12 (14.1%)	66 (10.2%)	
Biological sealants						
Never	140 (68.0%)	174 (64.0%)	176 (63.3%)	84 (66.7%)	574 (65.1%)	0.007
Occasionally (1–25%)	32 (15.5%)	62 (22.8%)	62 (22.3%)	27 (21.4%)	183 (20.7%)	
Sometimes (26–75%)	7 (3.4%)	16 (5.9%)	15 (5.4%)	10 (7.9%)	48 (5.4%)	
Frequently (76–99%)	9 (4.4%)	12 (4.4%)	17 (6.1%)	5 (4.0%)	43 (4.9%)	
Always	18 (8.7%)	8 (2.9%)	8 (2.9%)	0	34 (3.9%)	
Autologous tissue patches						
Never	134 (64.4%)	172 (64.2%)	147 (53.1%)	89 (71.2%)	542 (61.7%)	0.001
Occasionally (1–25%)	34 (16.3%)	51 (19.0%)	52 (18.8%)	21 (16.8%)	158 (18.0%)	
Sometimes (26–75%)	18 (8.7%)	18 (6.7%)	20 (7.2%)	5 (4.0%)	61 (6.9%)	
Frequently (76–99%)	10 (4.8%)	12 (4.5%)	38 (13.7%)	7 (5.6%)	67 (7.6%)	
Always	12 (5.8%)	15 (5.6%)	20 (7.2%)	3 (2.4%)	50 (5.7%)	
Prophylactic, intraperitoneal drainage						
Never	26 (12.6%)	47 (17.2%)	41 (14.7%)	9 (7.2%)	123 (13.9%)	0.003
Occasionally (1–25%)	25 (12.1%)	19 (7.0%)	26 (9.3%)	14 (11.2%)	84 (9.5%)	
Sometimes (26–75%)	8 (3.9%)	11 (4.0%)	18 (6.5%)	2 (1.6%)	39 (4.4%)	
Frequently (76–99%)	28 (13.5%)	27 (9.9%)	49 (17.6%)	11 (8.8%)	115 (13.0%)	
Always	120 (58.0%)	169 (61.9%)	145 (52.0%)	89 (71.2%)	523 (59.2%)	
Type of drain(s) regularly used						
Jackson–Pratt	65 (36.7%)	74 (33.5%)	134 (56.5%)	21 (18.3%)	294 (39.2%)	<0.001
Blake	53 (29.9%)	61 (27.6%)	94 (39.7%)	58 (50.4%)	266 (35.5%)	
Penrose	21 (11.9%)	36 (16.3%)	1 (0.4%)	21 (18.3%)	79 (10.5%)	
Other	37 (20.9%)	50 (22.6%)	3 (1.3%)	12 (10.4%)	102 (13.6%)	
Number of drain(s) regularly used						
1	35 (19.6%)	56 (25.8%)	101 (43.5%)	28 (24.3%)	220 (29.6%)	<0.001
2	119 (66.5%)	131 (60.4%)	121 (52.2%)	80 (69.6%)	451 (60.7%)	
≥3	18 (10.1%)	22 (10.1%)	5 (2.2%)	5 (4.3%)	50 (6.7%)	
Varies each case	7 (3.9%)	8 (3.7%)	5 (2.2%)	2 (1.7%)	22 (3.0%)	
Remove drains based on early (PoD ≤3) drain amylase values						
No	84 (46.4%)	112 (49.6%)	160 (68.4%)	56 (49.1%)	412 (54.6%)	<0.001
Yes	97 (53.6%)	114 (50.4%)	74 (31.6%)	58 (50.9%)	343 (45.4%)	
Preferred PoD drain removal, median (IQR)	5 (5–7)	5 (4–7)	5 (4–6)	7 (5–8)	5 (4–7)	<0.001

Table 3 Continued

Variable	Asia/Australia	Europe/Africa/ Middle East	North America	South/Central America	Overall	*P*-value
Prophylactic somatostatin analogues						
Never	63 (30.3%)	78 (28.7%)	152 (54.7%)	65 (51.2%)	358 (40.5%)	<0.001
Occasionally (1–25%)	42 (20.2%)	54 (19.9%)	72 (25.9%)	31 (24.4%)	199 (22.5%)	
Sometimes (26–75%)	26 (12.5%)	48 (17.6%)	23 (8.3%)	15 (11.8%)	112 (12.7%)	
Frequently (76–99%)	30 (14.4%)	37 (13.6%)	17 (6.1%)	12 (9.4%)	96 (10.8%)	
Always	47 (22.6%)	55 (20.2%)	14 (5.0%)	4 (3.1%)	120 (13.6%)	

of lymph nodes. Data for these surgeons also showed a trend towards lower rates of overall morbidity and mortality. In the current study, just 35.5% of surgeons met this criterion; in only a single region – North America – did the PD volume of >38% of surgeons surpass this cut-off.

Schmidt *et al.*[10] defined experienced surgeons as those with a career PD volume of ≥50 PDs; these surgeons were associated with significantly lower rates of overall morbidity, pancreatic leaks as defined by the International Study Group on Pancreatic Fistula (ISGPF), operative time, and mean intraoperative blood loss. Only 63.8% of surgeons in the present study met this criterion for the 'experienced surgeon', and as few as 36.5% of surgeons in South/Central America did so. Similar proportions of surgeons from each of the other three regions were found to have surpassed this cut-off (67.1–70.3%). A more refined approach within the work of Schmidt *et al.*[10] evaluated the number of PDs necessary for less experienced surgeons (<50 PDs) to achieve outcomes numerically equivalent to those obtained by experienced surgeons (≥50 PDs). Interestingly, these authors[10] considered that the performance of 60 PDs – the value derived by Tseng *et al.*[11] –was necessary for less experienced surgeons to achieve equivalent mortality rates.

Randomized controlled trials conducted during the contemporary ISGPF era have enabled unbiased comparisons of many intraoperative techniques and management options. One such comparison refers to the technique used for pancreatic anastomotic reconstruction. Meta-analyses of contemporary RCTs have concluded that the PG anastomotic technique is superior to PJ.[1,12,13] In an investigation of seven recent RCTs, Liu and colleagues reported that PG was associated with lower rates of clinically relevant pancreatic fistula, biliary fistula and intra-abdominal collections.[12] Furthermore, PG correlated positively with reduced hospital stay. Despite the preponderance of evidence suggesting the superiority of PG to PJ, the current study demonstrated that less than 10% of world surgeons prefer PG, whereas PJ is the anastomotic technique of choice for the overwhelming majority (88.7%). Stratification by region shows that PG is the primary choice for only 3.2% of North American surgeons, but is preferred by 16.5% of European/African/Middle Eastern surgeons. This may reflect a regional bias because every contemporary RCT establishing improved outcomes with PG has been conducted in either Europe[14–19] or the Middle East.[20]

Another operative issue of interest concerns the placement of trans-anastomotic stents. A recent meta-analysis of RCTs found external stents – versus no stents – to decrease the incidence of pancreatic fistula, lower overall morbidity and reduce the duration of hospital stay.[21] The rationale for external stenting includes the facilitation of precise suture placement, as well as the ability to divert or shunt proteolytic enzymes from the anastomotic site.[22] Although meta-analyses of contemporary RCTs demonstrate a benefit of external stents,[2,21] only 2.1% of international surgeons always use them. Even when avoiding absolutes, <20% of world surgeons selectively or always employ this technique. As with PG, there appears to be a trend towards regional bias; two[23,24] of the three recent RCTs reporting a benefit of external stenting were performed in Asian countries and none originated in North America. Consequently, Asian/Australian surgeons are most likely to use external stents selectively or always (22.5%), and North Americans are least likely to use external stents (17.7%). Perhaps even more notably, although Level I evidence suggests there is no difference in outcomes between cases in which internal stents are used and those in which no stents are used,[25] *internal* stents are utilized selectively or always by 57.7% of world PD surgeons.

The present study also evaluated the use of biological sealants, which are haemostatic agents used to augment the anastomotic connection. Biological sealants have been tested in two RCTs,[3,4] neither of which reported lower rates of anastomotic leak or complications with sealants. Despite these negative findings, the current study demonstrated that 34.9% of surgeons use biological sealants selectively or always. The continued use of sealants – despite the lack of apparent benefit – is particularly surprising when cost is considered. In 2004, a randomized trial by Lillemoe and colleagues reported the cost of fibrin glue to be US$328 per patient.[3] The administration of fibrin glue in every PD patient at a high-volume centre, such as Johns Hopkins Hospital (Baltimore, MD, USA), where approximately 300 PDs are performed per year, would cost approximately US$98 400 per year.

Another operative technique for reinforcing the pancreatic anastomosis concerns the use of autologous tissue patches. In this approach, the round ligament of the liver is detached from the abdominal wall and attached circumferentially at the PJ

anastomosis.[26] Thus far, evaluations of the efficacy of this practice in PD are limited to one retrospective review.[26] Although no Level I evidence supports this practice for PD, 38.3% of the world's PD surgeons employ this technique selectively or always. Support for this practice is particularly pronounced in North America, where nearly half of surgeons (46.9%) attest to using this approach selectively or always in PD.

Externalized intraperitoneal drains have traditionally accompanied PD. Recently, routine drainage was assessed in a randomized setting; results demonstrated that routine drainage was associated with fewer and less severe complications.[5] A secondary endpoint of that study referred to the specific investigation of the impact of drainage on the incidence of pancreatic fistula[6] and found that patients with negligible or low risk for the development of fistula (according to the Fistula Risk Score[27]) do not require drains, whereas those with moderate or high risk for fistula benefit from drain placement. Although that study[6] concluded that selective drainage was beneficial, the present study demonstrates that only 26.9% of the world practises selective drainage; furthermore, 13.9% of PD surgeons never place a drain prophylactically, regardless of the patient's degree of risk.

Another management decision involves the PoD of drain removal. A contemporary, randomized trial by Bassi and colleagues evaluated the efficacy of early drain removal based upon PoD 1 drain amylase values.[28] The authors reported that early drain removal was associated with significantly lower rates of pancreatic fistula, abdominal complications and pulmonary complications.[28] Despite these findings, the current study demonstrates that less than half (45.4%) of the surgeons surveyed remove drains based on early (PoD $\leq$3) drain amylase values. This discordance with Level I evidence was particularly pronounced in North America, where fewer than a third (31.6%) of surgeons follow this practice; conversely, European/African/Middle Eastern and Asian/Australian surgeons take this approach in 50.4% and 53.6% of cases, respectively. This may once again reflect regional biases. The first major prospective trial to demonstrate a benefit of early drain removal was conducted by Kawai *et al.* in Japan,[29] and the only randomized trial to address this topic was conducted in Verona, Italy.[28] Notably, no randomized trials to date have scrutinized this practice in North America.

One of the more contentious management issues upon which pancreatic surgeons must make decisions regards the administration of prophylactic somatostatin analogues, such as octreotide. At least eight high-volume (>100 patients) RCTs have investigated the use of octreotide with inconclusive findings.[30] However, much of this incongruence can be attributed to the evolution of nomenclature for postoperative complications. For example, before the advent of the ISGPF nomenclature for fistulae, studies did not differentiate between the incidence of innocuous biochemical (Grade A) and clinically relevant (Grades B and C) fistulae. Since the emergence of the ISGPF, no high-volume, randomized trials have found octreotide to be associated with lower rates of clinically relevant fistula; however, the largest retrospective study to evaluate octreotide showed it to be associated with a reduced incidence of biochemical fistula and, in fact, higher rates of clinically relevant fistula.[30]

In the present study, the prevalence of somatostatin analogue utilization appeared to correlate with the regional locations – as well as the findings – of randomized trials. European/African/Middle Eastern surgeons selectively or always administer prophylactic somatostatin analogues 71.3% of the time and the first four randomized trials to associate octreotide with improved outcomes were conducted at European centres. By contrast, only 45.3% of North American surgeons administer somatostatin analogues selectively or always; this may reflect the inconclusive findings regarding the efficacy of octreotide in high-volume, randomized North American studies. A recent study conducted by surgeons at the Memorial Sloan–Kettering Cancer Center investigated the new somatostatin analogue, pasireotide, and reported that it was associated with a decreased rate of clinically significant pancreatic fistula; however, pasireotide has not been evaluated in a multicentre setting.[31] Overall, the literature regarding this approach is inconclusive and its administration seems to be heavily influenced by the geographical location of relevant randomized studies.

There are several noteworthy limitations to this study. Firstly, it relied on surgeons' self-reports of their experience and practice patterns. The possibility that surgeons may have exaggerated their annual and career volumes of PD emphasizes how few surgeons have actually surpassed the quantity of PDs considered necessary to surmount the learning curve and qualify as a high-volume surgeon. Secondly, as expected, missing responses were occasionally encountered, although approximately 99% of the data fields were completed. As this study was heavily focused on investigating approaches that may influence pancreatic fistula development, some operative techniques were not explored (e.g. pylorus-preserving versus classical PD). Furthermore, given the study's inability to establish a firm denominator, the degree to which this reflects global practice cannot be definitively ascertained. Additionally, this study exclusively surveyed members of surgical societies, which limits the full extent of its reach. Lastly, this study's descriptive nature does not allow the direct linkage of surgical volume and practice patterns to actual outcomes.

In summary, this study defined the demographics and practice patterns of surgeons performing PD around the world by examining surgeons who are members of gastrointestinal and oncologic surgical societies. Surprisingly low annual and career volumes were reported, which may explain the significant heterogeneity in the morbidity and mortality rates published throughout the surgical literature. This study also demonstrated considerable variation in operative and management decisions, underscoring the numerous options available to surgeons who perform this operation. Many of these choices contrast with established randomized evidence, and this incongruence is particularly stark in regions in which a practice either has not been

tested or has produced alternative findings in a randomized setting. It may be that personal habits or institutional and training influences play a role in explaining why the clinical practice of many surgeons has not evolved to fall in line with the highest-level evidence. It remains to be seen whether the standardization of these diverse clinical practices may lead to improved, or more consistent, outcomes. Thus, the findings presented here may have implications on the design of future trials regarding operative and management strategies in PD.

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Conflicts of interest

None declared.

References

1. Menahem B, Guittet L, Mulliri A, Alves A, Lubrano J. (2015) Pancreaticogastrostomy is superior to pancreaticojejunostomy for prevention of pancreatic fistula after pancreaticoduodenectomy: an updated meta-analysis of randomized controlled trials. *Ann Surg* 261:882–887.
2. Wang Q, He XR, Tian JH, Yang KH. (2013) Pancreatic duct stents at pancreaticoduodenectomy: a meta-analysis. *Dig Surg* 30:415–424.
3. Lillemoe KD, Cameron JL, Kim MP, Campbell KA, Sauter PK, Coleman JA *et al.* (2004) Does fibrin glue sealant decrease the rate of pancreatic fistula after pancreaticoduodenectomy? Results of a prospective randomized trial. *J Gastrointest Surg* 8:766–772.
4. Martin I, Au K. (2013) Does fibrin glue sealant decrease the rate of anastomotic leak after a pancreaticoduodenectomy? Results of a prospective randomized trial. *HPB* 15:561–566.
5. Van Buren G II, Bloomston M, Hughes SJ, Winter J, Behrman SW, Zyromski NJ *et al.* (2014) A randomized prospective multicenter trial of pancreaticoduodenectomy with and without routine intraperitoneal drainage. *Ann Surg* 259:605–612.
6. McMillan MT, Fisher WE, Van Buren G II, McElhany A, Bloomston M, Hughes SJ *et al.* (2015) The value of drains as a fistula mitigation strategy for pancreatoduodenectomy: something for everyone? Results of a randomized prospective multi-institutional Study. *J Gastrointest Surg* 19:21–31.
7. Bassi C, Dervenis C, Butturini G, Fingerhut A, Yeo C, Izbicki J *et al.* (2005) Postoperative pancreatic fistula: an international study group (ISGPF) definition. *Surgery* 138:8–13.
8. Wente MN, Bassi C, Dervenis C, Fingerhut A, Gouma DJ, Izbicki JR *et al.* (2007) Delayed gastric emptying (DGE) after pancreatic surgery: a suggested definition by the International Study Group of Pancreatic Surgery (ISGPS). *Surgery* 142:761–768.
9. Wente MN, Veit JA, Bassi C, Dervenis C, Fingerhut A, Gouma DJ *et al.* (2007) Postpancreatectomy hemorrhage (PPH): an International Study Group of Pancreatic Surgery (ISGPS) definition. *Surgery* 142:20–25.
10. Schmidt CM, Turrini O, Parikh P, House MG, Zyromski NJ, Nakeeb A *et al.* (2010) Effect of hospital volume, surgeon experience, and surgeon volume on patient outcomes after pancreaticoduodenectomy: a single-institution experience. *Arch Surg* 145:634–640.
11. Tseng JF, Pisters PW, Lee JE, Wang H, Gomez HF, Sun CC *et al.* (2007) The learning curve in pancreatic surgery. *Surgery* 141:694–701.
12. Liu FB, Chen JM, Geng W, Xie SX, Zhao YJ, Yu LQ *et al.* (2015) Pancreaticogastrostomy is associated with significantly less pancreatic fistula than pancreaticojejunostomy reconstruction after pancreaticoduodenectomy: a meta-analysis of seven randomized controlled trials. *HPB* 17:123–130.
13. Que W, Fang H, Yan B, Li J, Guo W, Zhai W *et al.* (2015) Pancreaticogastrostomy versus pancreaticojejunostomy after pancreaticoduodenectomy: a meta-analysis of randomized controlled trials. *Am J Surg* 209:1074–1082.
14. Duffas JP, Suc B, Msika S, Fourtanier G, Muscari F, Hay JM *et al.* (2005) A controlled randomized multicenter trial of pancreatogastrostomy or pancreatojejunostomy after pancreatoduodenectomy. *Am J Surg* 189:720–729.
15. Bassi C, Falconi M, Molinari E, Salvia R, Butturini G, Sartori N *et al.* (2005) Reconstruction by pancreaticojejunostomy versus pancreaticogastrostomy following pancreatectomy: results of a comparative study. *Ann Surg* 242:767–771; discussion 771–773.
16. Fernandez-Cruz L, Cosa R, Blanco L, Lopez-Boado MA, Astudillo E. (2008) Pancreatogastrostomy with gastric partition after pylorus-preserving pancreatoduodenectomy versus conventional pancreatojejunostomy: a prospective randomized study. *Ann Surg* 248:930–938.
17. Wellner UF, Sick O, Olschewski M, Adam U, Hopt UT, Keck T. (2012) Randomized controlled single-center trial comparing pancreatogastrostomy versus pancreaticojejunostomy after partial pancreatoduodenectomy. *J Gastrointest Surg* 16:1686–1695.
18. Topal B, Fieuws S, Aerts R, Weerts J, Feryn T, Roeyen G *et al.* (2013) Pancreaticojejunostomy versus pancreaticogastrostomy reconstruction after pancreaticoduodenectomy for pancreatic or periampullary tumours: a multicentre randomised trial. *Lancet Oncol* 14:655–662.
19. Figueras J, Sabater L, Planellas P, Munoz-Forner E, Lopez-Ben S, Falgueras L *et al.* (2013) Randomized clinical trial of pancreaticogastrostomy versus pancreaticojejunostomy on the rate and severity of pancreatic fistula after pancreaticoduodenectomy. *Br J Surg* 100:1597–1605.
20. El Nakeeb A, Hamdy E, Sultan AM, Salah T, Askr W, Ezzat H *et al.* (2014) Isolated Roux loop pancreaticojejunostomy versus pancreaticogastrostomy after pancreaticoduodenectomy: a prospective randomized study. *HPB* 16:713–722.
21. Hong S, Wang H, Yang S, Yang K. (2013) External stent versus no stent for pancreaticojejunostomy: a meta-analysis of randomized controlled trials. *J Gastrointest Surg* 17:1516–1525.

22. McMillan MT, Vollmer CM Jr. (2014) Predictive factors for pancreatic fistula following pancreatectomy. *Langenbecks Arch Surg* 399:811–824.
23. Poon RT, Fan ST, Lo CM, Ng KK, Yuen WK, Yeung C *et al.* (2007) External drainage of pancreatic duct with a stent to reduce leakage rate of pancreaticojejunostomy after pancreaticoduodenectomy: a prospective randomized trial. *Ann Surg* 246:425–433.
24. Motoi F, Egawa S, Rikiyama T, Katayose Y, Unno M. (2012) Randomized clinical trial of external stent drainage of the pancreatic duct to reduce postoperative pancreatic fistula after pancreaticojejunostomy. *Br J Surg* 99:524–531.
25. Winter JM, Cameron JL, Campbell KA, Chang DC, Riall TS, Schulick RD *et al.* (2006) Does pancreatic duct stenting decrease the rate of pancreatic fistula following pancreaticoduodenectomy? Results of a prospective randomized trial. *J Gastrointest Surg* 10:1280–1290.
26. Iannitti DA, Coburn NG, Somberg J, Ryder BA, Monchik J, Cioffi WG. (2006) Use of the round ligament of the liver to decrease pancreatic fistulas: a novel technique. *J Am Coll Surg* 203:857–864.
27. Callery MP, Pratt WB, Kent TS, Chaikof EL, Vollmer CM Jr. (2013) A prospectively validated clinical risk score accurately predicts pancreatic fistula after pancreatoduodenectomy. *J Am Coll Surg* 216:1–14.
28. Bassi C, Molinari E, Malleo G, Crippa S, Butturini G, Salvia R *et al.* (2010) Early versus late drain removal after standard pancreatic resections: results of a prospective randomized trial. *Ann Surg* 252: 207–214.
29. Kawai M, Tani M, Terasawa H, Ina S, Hirono S, Nishioka R *et al.* (2006) Early removal of prophylactic drains reduces the risk of intra-abdominal infections in patients with pancreatic head resection: prospective study for 104 consecutive patients. *Ann Surg* 244:1–7.
30. McMillan MT, Christein JD, Callery MP, Behrman SW, Drebin JA, Kent TS *et al.* (2014) Prophylactic octreotide for pancreatoduodenectomy: more harm than good? *HPB* 16:954–962.
31. Allen PJ, Gonen M, Brennan MF, Bucknor AA, Robinson LM, Pappas MM *et al.* (2014) Pasireotide for postoperative pancreatic fistula *N Engl J Med* 370:2014–2022.