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CLINICAL PRACTICE GUIDELINE

The São Paulo International Consensus on Minimally Invasive Pancreatic Surgery for Cancer

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Abstract

Background: Although minimally invasive surgery is widely accepted across surgical disciplines, its role in pancreatic cancer continues to be debated. The objective of the São Paulo Consensus on Minimally Invasive Pancreatic Surgery (MIPS) was to establish consensus statements on the use of MIPS for pancreatic cancer, integrating contemporary evidence and recent advances.

Methods: A scoping literature review informed statement development across five thematic groups: (1) Left Pancreatectomy for Pancreatic Cancer, (2) Pancreatoduodenectomy and Total Pancreatectomy for Pancreatic Cancer, (3) Neuroendocrine Pancreatic Tumors, (4) Patient Evaluation and Surgical Technique, and (5) Implementation, Training, and Innovation. A three-round modified Delphi process was conducted with an international panel of 52 expert pancreas surgeons. Consensus was defined as ≥90 % agreement.

Results: From 2590 publications, 185 studies were selected for inclusion. Fifty-two hepatopancreatobiliary surgeons, with a median of 22 years of experience, achieved consensus through a three-round Delphi process. Ultimately, 22 of the initial 28 statements met the ≥90 % agreement threshold. The resulting recommendations provide evidence-based guidance on minimally invasive pancreas resection for cancer, including neuroendocrine tumors, patient evaluation, program implementation, and innovation.

Discussion: The São Paulo Consensus provides contemporary, evidence-based recommendations to guide the safe and judicious adoption, implementation, and practice of minimally invasive techniques.

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Introduction

Pancreatic cancer remains one of the most lethal gastrointestinal malignancies, with limited improvements in long-term survival despite advances in systemic therapy and multidisciplinary care.[1] Surgical resection is the cornerstone of curative-intent treatment. However, pancreatic surgery is technically complex and associated with significant perioperative morbidity.[2,3]

Over the past two decades, minimally invasive techniques have transformed the surgical management of several gastrointestinal cancers. Their application to pancreatic procedures, however, has been cautious and heterogeneous, reflecting the steep learning curve, the need for specialized training, and the challenges of ensuring oncologic adequacy in technically demanding operations.[4] At the same time, rapid technological advances, including robotic platforms and advanced imaging modalities, have broadened the possibilities of minimally invasive pancreatic surgery (MIPS), raising new questions regarding indications, safety, and training requirements.[5]

While previous international initiatives, such as the Miami and Brescia consensus meetings, established essential foundations for minimally invasive pancreatic surgery, the field continues to evolve.[6,7] Expanding evidence, including multiple RCTs addressing both left pancreatectomy and pancreatoduodenectomy, coupled with the integration of perioperative strategies and new technologies, underscores the need for updated, comprehensive, and globally informed recommendations.[8–10] As prior guidelines focused on technical feasibility, this consensus emphasized the application of MIPS to pancreatic cancer, including oncologic outcomes and training and programmatic requirements. It further prioritized comparability and equivalence rather than superiority.

The objective of the present consensus was to develop practice-oriented recommendations for minimally invasive pancreatic surgery for pancreatic cancer, using a structured Delphi process and an international expert panel. The São Paulo International Consensus aimed to address critical questions regarding surgical indications, technical approaches, perioperative management, and programmatic implementation, thereby providing a framework to guide surgeons, institutions, and policymakers in the safe and effective adoption of MIPS in oncologic practice.

Methods

Study design

This study was developed as a three-round modified Delphi process. A total of 52 experts from multiple continents participated, ensuring a broad representation of perspectives and practices. The work was organized into five thematic groups, each led by a senior expert: (1) Left Pancreatectomy for

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Pancreatic Cancer, (2) Pancreatoduodenectomy and Total Pancreatectomy for Pancreatic Cancer, (3) Neuroendocrine Pancreatic Tumors, (4) Patient Evaluation and Surgical Technique, and (5) Implementation, Training, and Innovation.

Initially, a dedicated committee composed of the five thematic group leaders formulated key clinical questions relevant to cancer care, which were then reviewed and refined by the steering committee. Next, a scoping literature review was performed to identify and summarize evidence relevant to the clinical questions. Clinical questions were organized by thematic topics as detailed above. For each topic, expert teams, comprising two to four hepatobiliary surgeons, were assigned to evaluate the available evidence. Each of the five thematic groups conducted structured online discussions to review the evidence and critically refine draft statements. The steering committee then reviewed the draft statements, incorporating additional clarifications or contextual remarks when necessary to ensure consistency, accuracy, and transparency across all recommendations. These draft recommendations were subsequently submitted to the larger expert panel for structured consensus-building using the Delphi method (Fig. 1).

Literature search

Literature searches were conducted in PubMed and included studies published between July 2015 and June 2025. Studies were eligible if they focused on adult patients (≥18 years) undergoing pancreatic surgery for cancer, with emphasis on minimally invasive approaches (laparoscopic or robotic). In addition, studies addressing innovation, training, surgical technique, or perioperative management applicable to minimally invasive pancreatic surgery were included. Eligible studies were required to report perioperative outcomes (e.g., operative time, blood loss, morbidity, mortality, hospital stay) and/or oncologic outcomes (e.g., margin status, adjuvant therapy rate, disease-free or overall survival). Controlled trials and prospective or retrospective observational studies were considered for inclusion. Case reports, conference abstracts, and articles without full-text availability were excluded. Only full-text articles published in English were considered. The search strategy was adapted for each of the five thematic groups, combining Medical Subject Headings (MeSH) with free-text terms (Supplemental Table 1, Supplemental Figure 1).

Data extraction and summary

Data extraction was performed by a team of 11 MD/PhD students under the direct supervision of expert panel members. The extracted data underwent qualitative synthesis to ensure accurate interpretation and contextualization within the broader scope of existing literature. The selected evidence was summarized in tables to facilitate discussion. During discussion, members of the expert panel were able to add additional sources they identified as relevant to the clinical questions, to maximize inclusion and consideration of potentially relevant evidence.

Expert panel

The expert panel consisted of 52 hepatopancreatobiliary surgeons. Experts were selected based on their recognized academic and clinical expertise in hepatopancreatobiliary surgery, active involvement in minimally invasive pancreatic surgery, and representation from leading institutions across all continents. There is no agreed-upon cutoff for Delphi panel size. However, recommendations have been made for a minimum of 10 panelists for homogeneous groups and 30 panelists for heterogeneous groups.[11–13] Therefore, our diverse international panel of 52 surgeons was deemed appropriate in size.

Criteria for consensus

Consensus was defined using an a priori agreement threshold of 90 %. This threshold has been used as a reliable indicator of consensus in previous Delphi studies.[14]

Delphi survey rounds

A modified Delphi method was employed, involving three rounds of anonymous voting and feedback. The survey was distributed via an online form (Qualtrics). For each round, the panel was given one week to respond. Non-respondents received additional reminders.

The first survey included 28 statements. Respondents were asked to agree with minor revisions or disagree. In the case of disagreement with one of the statements, a comment was mandatory to allow for appropriate editing of the statements for each round. After each round, the percentage agreement was tabulated and reported to participants anonymously in the next round. In rounds 2 and 3, statements that received ≥90 % agreement in prior rounds were excluded from additional rounds of voting. Statements that received <90 % agreement were revised substantially by the steering committee, based on the survey comments, and included in subsequent rounds of voting. Statements that achieved ≥90 % in the previous round were included in the subsequent survey for reference, with an option to comment to allow for final review by the experts.

Statistical analysis

Descriptive statistics were tabulated to summarize results. Counts and percentages were used to summarize categorical variables, and medians (ranges) were used to summarize continuous variables. Cronbach's alpha was used as a measure of internal consistency in the first round, with a value above 0.7 indicating acceptable reliability and a value above 0.9 considered excellent.[15]

Results

Literature review

The literature search retrieved 244 articles for left pancreatectomy, of which 43 were selected after screening; 450 articles for pancreatoduodenectomy and total pancreatectomy, of which 68

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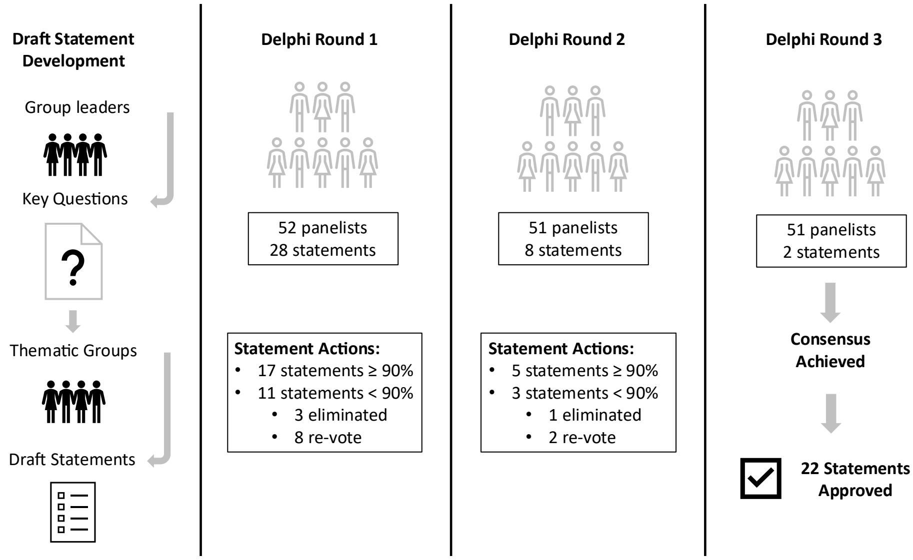

Figure 1 Summary of Study Design and the Delphi Process

were included; and 462 articles for neuroendocrine pancreatic tumors, of which 12 met the eligibility criteria. In the domain of patient evaluation and surgical technique, searches identified more than 1100 publications, of which 28 were selected. Finally, for implementation, training, and innovation, 334 articles were retrieved, with 34 studies ultimately included.

Expert characteristics

A total of 52 international experts participated in the São Paulo Consensus. Experts represented 17 countries across six continents, including North and South America, Europe, Asia, Africa, and Oceania. The median professional experience was 22 years (range, 3—50 years). Regarding the pooled practice of the participants with respect to surgery for pancreatic cancer, robotic procedures represented a median of 20 % of cases (range, 0—90 %), while laparoscopic procedures similarly represented a median of 20 % (range, 0—90 %) of cases. Open surgery remained the predominant approach, with a median of 52.5 % (range, 0—100 %) of cases.

Survey rounds

The response rate was 100 % for the first round. Of 28 statements, 17 received ≥90 % agreement and were excluded from subsequent rounds. Eleven statements received <90 % agreement. Of these statements, two were combined based on expert feedback, and one was eliminated, leaving eight statements to be re-voted in round 2. Cronbach's alpha was 0.85.

The response rate was 98 % for the second round. Of eight statements, 5 received ≥90 % agreement by experts and were excluded from subsequent rounds. Three statements received <90 % agreement. Of these statements, one was eliminated, and two were revised based on expert feedback for re-voting in round 3. The response rate was 98 % for the third round. Of the two statements, both received <90 % agreement and were eliminated based on expert feedback.

Section 1: Left Pancreatectomy for Pancreatic Cancer

Finalized statements regarding left pancreatectomy for pancreatic cancer are summarized in Table 1. For patients undergoing left pancreatectomy, resections are defined as follows: type 1 refers to pancreatic tail resection (resection up to less than half of the distance between the pancreatic tail edge and the left border of the SMV), type 2 refers to pancreatic body and tail resection (resection up to the left border of the SMV), type 3 refers to pancreatic neck, body, and tail resection (resection past the right border of the SMV and to the left border of the gastroduodenal artery), and type 4 refers to extended pancreatic neck, body, and tail resection (resection up to the right of the gastroduodenal artery).[16] Resectability is defined throughout according to NCCN criteria.[17]

In patients with resectable distal pancreatic ductal adenocarcinoma, existing evidence demonstrates that minimally invasive left pancreatectomy is comparable to open surgery with respect to R0 resection rates and lymph node yield, and may offer advantages in terms of blood loss and length of stay.[8,18] While the LEOPARD trial demonstrated faster functional recovery in the MIDP group, the DIPLOMA trial found equivalent time to functional recovery.[8,18,19] Though high-level evidence exists for short-term outcomes, there is a need for further evidence examining differences in longer-term survival outcomes.

In terms of borderline and locally advanced disease, venous involvement has been identified as a risk factor for conversion to open surgery in MIDP in several studies.[19—21] Limited studies indicate that MIDP with venous resection and reconstruction

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appears feasible and may be facilitated by the robotic approach.[22–24] However, it should be performed only by surgeons with significant experience in MIS vascular and pancreas techniques. The current literature lacks robust evidence regarding MIS in the setting of major arterial involvement. The complexity of tumors with arterial involvement necessitates a high level of surgical expertise, and the learning curve is particularly important. As such, the use of MIS in this setting may be appropriate only in the setting of prospective studies, and at high-volume centers that participate in registries, rigorously monitor outcomes, and have surgeons with expertise in both pancreatic and vascular reconstruction using minimally invasive approaches.

Evidence specific to patients who have undergone neoadjuvant therapy is largely retrospective, with no large RCTs exclusively evaluating MIDP after neoadjuvant therapy.[25] However, based on more general evidence establishing the comparability of MIDP and ODP, and retrospective analysis specific to those who have undergone neoadjuvant therapy, MIDP may be considered an alternative to ODP in this subgroup.

Regarding the comparison between robotic and laparoscopic approaches for distal pancreatectomy, subgroup analysis of the DIPLOMA trial demonstrated no difference between groups in terms of operative time, blood loss, conversion, major complications, time to recovery, readmission, and ninety-day mortality.[8] Propensity-matched cohorts and meta-analyses show equivalent oncologic outcomes, with similar R0 rates and lymph nodes harvested.[26–28] For extended resections, the only comparative study identified was a propensity-matched retrospective large multicenter cohort study, which found robotic left pancreatectomy (RLP) to be comparable to laparoscopic left pancreatectomy (LLP) in terms of major morbidity, blood loss, conversion rates, hospital stay, and 30-day/in-hospital mortality.[29]

Section 2: Pancreatoduodenectomy and Total Pancreatectomy for Pancreatic Cancer

Finalized statements addressing pancreatoduodenectomy and total pancreatectomy for pancreatic cancer are summarized in Table 2. Existing evidence demonstrates that, in general, MIPD and OPD can achieve similar perioperative, oncologic, and long-term outcomes for resectable pancreatic head adenocarcinoma.[10,30–36] Evidence supports MIPD as a safe, effective alternative to OPD in well-selected patients at high-volume centers with established expertise.[30–32,34] Outcomes depend on surgeon experience and institutional volume. MIPD has a steep learning curve for both the surgeon and the center, and less-experienced centers do not demonstrate benefits, but potentially increase morbidity and mortality for MIPD in general.

Evidence specific to borderline resectable cancers and those with arterial involvement is more limited.[37,38] While minimally invasive approaches with vascular resection are potentially feasible in expert hands, it is crucial to emphasize that the technical complexity of borderline resectable cases necessitates extensive surgeon experience with both technical and intraoperative judgment factors. When resectability is uncertain or vascular involvement is extensive, open surgery remains the preferred approach to ensure complete oncologic clearance and vascular control.

In patients undergoing pancreatoduodenectomy following neoadjuvant chemotherapy, current evidence indicates that MIPD and OPD yield comparable outcomes for resectable disease, including postoperative complications, POPF, and mortality.[39]

In terms of robotic and laparoscopic approaches for resectable pancreatic head disease, studies show RPD and LPD have comparable R0 resection rates, lymph node harvest, complications (including pancreatic fistula and delayed gastric emptying), 90-day mortality, and overall survival for pancreatic ductal adenocarcinoma.[40–46] RPD has been linked to perioperative benefits over LPD, including shorter operative times, lower conversion rates, less blood loss, and slightly higher lymph node harvest.[40–46,47] While RPD may offer technical advantages, such as improved dexterity and visualization, current evidence does not conclusively establish its superiority over LPD.

While high-level evidence is limited, current data support that minimally invasive total pancreatectomy may be performed safely and effectively in experienced centers, with comparable oncologic and survival outcomes to open surgery.[47,48] Further prospective randomized trials are warranted to confirm these findings and delineate optimal patient selection criteria.

Section 3: Neuroendocrine Pancreatic Tumors

Finalized statements addressing neuroendocrine pancreatic tumors are summarized in Table 3. For pancreatic neuroendocrine tumors amenable to enucleation, minimally invasive enucleation, compared with open enucleation, has been associated, in some studies, with lower blood loss and shorter hospital stay, but no differences have been shown in terms of overall complications or pancreatic fistula.[49–51] While IOUS is valuable in both open and minimally invasive approaches, its role becomes particularly central in minimally invasive surgery, where direct manual palpation is not available. In this context, IOUS facilitates pancreatic parenchyma preservation and accurately assesses distance from the pancreatic duct.[52–54]

In terms of robotic and laparoscopic approaches for left-sided neuroendocrine tumors, the existing body of literature consists of few studies with direct comparison and an overall low sample size.[55,56] RDP may offer technical advantages, such as improved dexterity and visualization.[57] Limited retrospective studies indicate that RDP is associated with a higher spleen-preserving rate, and possibly reduced operative time, less blood loss, and shorter hospital stays compared to LDP.[58–62]

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Table 1 Left Pancreatectomy for Pancreatic Cancer

Question and Statement	R1 (%)	R2 (%)
In patients with resectable distal pancreatic ductal adenocarcinoma requiring body and tail resection (Type 1–2), is minimally invasive distal pancreatectomy (MIDP) comparable to open distal pancreatectomy (ODP)? **Statement 1: In patients with resectable distal pancreatic ductal adenocarcinoma requiring resection of the pancreatic body and tail (Types 1–2), minimally invasive distal pancreatectomy (MIDP) demonstrates non-inferiority to open distal pancreatectomy (ODP) in terms of short-term oncologic outcomes, overall complication rates, and overall survival, while possibly offering faster functional recovery.**	**96**	
In patients with resectable distal pancreatic ductal adenocarcinoma requiring extended pancreatic neck, body and tail resection (Type 3), is MIDP comparable to ODP? **Statement 2: In patients with resectable distal pancreatic ductal adenocarcinoma requiring extended resection of the pancreatic neck, body, and tail (Type 3), minimally invasive distal pancreatectomy (MIDP) can be performed with oncologic results comparable to open surgery, in high-volume centers that participate in registries and/or systematically monitor outcomes.**	**90**	
In patients with borderline-resectable distal pancreatic adenocarcinoma with venous involvement, is minimally invasive distal pancreatectomy (MIDP) comparable to open distal pancreatectomy (ODP)? **Statement 3: For patients with borderline resectable distal pancreatic ductal adenocarcinoma involving the superior mesenteric or portal vein (SMV/PV), evidence is insufficient to establish the comparability of minimally invasive distal pancreatectomy (MIDP) to open distal pancreatectomy (ODP). In these settings, MIDP should be performed only in selected patients by experienced surgeons, and at high-volume centers that participate in registries and/or rigorously monitor outcomes, or under the auspices of a prospective study.**	**92**	
In patients with locally advanced distal pancreatic adenocarcinoma including those with central arterial involvement (CA and/or SMA) is minimally invasive distal pancreatectomy (MIDP) comparable to open distal pancreatectomy (ODP)? **Statement 4: For patients with distal pancreatic ductal adenocarcinoma involving major arterial structures, evidence is insufficient to establish the comparability of minimally invasive distal pancreatectomy (MIDP) to open distal pancreatectomy (ODP). In these settings, MIDP should be performed only in selected patients by experienced surgeons, and at high-volume centers that participate in registries and/or rigorously monitor outcomes, or under the auspices of a prospective study. ODP remains the preferred approach when arterial resection is necessary.**	**90**	
In patients with distal pancreatic adenocarcinoma planned for resection after neoadjuvant or primary chemotherapy, is MIDP comparable to ODP? **Statement 5: In patients undergoing resection for distal pancreatic ductal adenocarcinoma after neoadjuvant chemotherapy, minimally invasive distal pancreatectomy (MIDP) is an alternative to open distal pancreatectomy (ODP) at high-volume centers that participate in registries and/or systematically monitor outcomes.**	**98**	
In patients with technically resectable distal pancreatic ductal adenocarcinoma requiring body and tail resection (Type 1–2), with or without vascular resection, is robotic distal pancreatectomy (RDP) equivalent to laparoscopic distal pancreatectomy (LDP)? **Statement 6: For patients with resectable distal pancreatic ductal adenocarcinoma requiring resection of the pancreatic body and tail (Types 1–2), robotic distal pancreatectomy can be considered equivalent to laparoscopic distal pancreatectomy.**	**98**	
In patients with technically resectable distal pancreatic ductal adenocarcinoma requiring extended pancreatic neck, body and tail resection (Type 3–4), with or without vascular resection, is RDP equivalent to LDP ? **Statement 7: For resectable distal pancreatic ductal adenocarcinoma requiring extended resection of the pancreatic neck, body, and tail (Type 3), both laparoscopic and robotic distal pancreatectomy are feasible, though no direct comparative studies exist. The choice of approach should be guided by institutional expertise and the surgeon's experience.**	**83**	**98**

Notes: For statements 2 and 7, in the original version of the statements, type 4 resections were included, however they were removed as a result of expert feedback in round 1, based on the concern that there was insufficient evidence regarding type 4 resections.

Regarding minimally invasive approaches for neuroendocrine tumors of the pancreatic head, findings are constrained by a lack of randomized prospective data, as published MIPD vs OPD RCTs contain few if any cases of pNET histology. However, retrospective data suggest comparable postoperative morbidity, oncologic outcomes, and survival.[63–67] Studies show RPD and LPD have comparable 90-day mortality, major complications, and R0 resection rates.[40–46]

Section 4: Patient Evaluation and Surgical Technique

Finalized statements addressing patient evaluation and surgical technique are summarized in Table 4. The benefits of multimodal prehabilitation can enhance surgical resilience and recovery.[68–71] While systematic reviews indicate possible benefits for treatment adherence, direct evidence on post-resection adjuvant therapy rates and quality of life is lacking.[71] Findings are constrained by small sample sizes, heterogeneous protocols, and limited high-quality randomized trials, underscoring the need for standardized, large-scale studies in this setting.[69,70]

Evidence regarding conversion is drawn mainly from retrospective data. In general, conversion has not been associated with impaired oncologic prognosis but has been associated with worse short-term outcomes compared to MIS completed procedures.[72–77] Urgent conversion is associated with a

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Table 2 Pancreatoduodenectomy and Total Pancreatectomy for Pancreatic Cancer

Question and Statement	R1 (%)	R2 (%)
In patients with resectable pancreatic head adenocarcinoma, is minimally invasive pancreatoduodenectomy (MIPD) comparable to open pancreatoduodenectomy (OPD)? Statement 8: **In patients with resectable pancreatic head adenocarcinoma, minimally invasive pancreatoduodenectomy (MIPD) demonstrates perioperative and oncologic outcomes comparable to open pancreatoduodenectomy (OPD) when performed at high-volume centers that participate in registries and systematically monitor outcomes. The choice of approach should be determined by patient characteristics, surgeon proficiency, and programmatic capabilities.**	**90**	
In patients with anatomical borderline pancreatic head adenocarcinoma, with or without the need for venous resection, is MIPD comparable to OPD? Statement 9: **In patients with borderline resectable pancreatic head adenocarcinoma - with or without the need for venous resection - there is limited evidence to support MIPD. Its use may be appropriate at high-volume centers that participate in registries and systematically monitor outcomes, or under the auspices of an investigational study, and by surgeons with expertise in both pancreatic and vascular reconstruction using minimally invasive approaches. Current evidence is limited to retrospective series, and open pancreatoduodenectomy remains the preferred approach in this setting.**	**75** **84**	**98**
In patients with pancreatic head adenocarcinoma requiring arterial vascular resection, is MIPD comparable to OPD? Statement 10: **In patients with pancreatic head adenocarcinoma requiring arterial vascular resection, minimally invasive pancreatoduodenectomy (MIPD) should be considered investigational. Its use may be appropriate only in the setting of prospective studies, and/or at high-volume centers that participate in registries, rigorously monitor outcomes, and have surgeons with expertise in both pancreatic and vascular reconstruction using minimally invasive approaches. Current evidence is limited to retrospective series, and open pancreatoduodenectomy remains the preferred approach in this setting.**	**73** **51**	**96**
In patients scheduled for pancreatoduodenectomy after neoadjuvant chemotherapy, is MIPD comparable to OPD? Statement 11: **In patients undergoing pancreatoduodenectomy following neoadjuvant chemotherapy, current evidence indicates that minimally invasive pancreatoduodenectomy (MIPD) and open pancreatoduodenectomy (OPD) yield comparable perioperative outcomes. However, the impact of preoperative chemoradiotherapy on the safety and feasibility of MIPD remains poorly studied and warrants further investigation.**	**96**	
In patients with resectable pancreatic head adenocarcinoma, is laparoscopic pancreatoduodenectomy (LPD) equivalent to robotic pancreatoduodenectomy (RPD) whenever feasible? Statement 12: **In patients with resectable pancreatic head adenocarcinoma, robotic pancreatoduodenectomy (RPD) and laparoscopic pancreatoduodenectomy (LPD) demonstrate comparable perioperative safety, oncologic adequacy, and long-term survival when performed at high-volume centers that systematically monitor outcomes, and by surgeons who have completed the learning curve.**	**84**	**90**
In patients requiring total pancreatectomy for adenocarcinoma, is minimally invasive total pancreatectomy (MITP) comparable to open total pancreatectomy (OTP)? Statement 13: **In selected patients, minimally invasive total pancreatectomy (MITP) demonstrates perioperative safety, oncologic adequacy, and long-term survival outcomes comparable to open total pancreatectomy (OTP) for adenocarcinoma. MITP may also offer advantages in postoperative recovery; however, evidence remains limited and further prospective studies are needed.**	**92**	

Notes: For statement 9, two separate statements were included in round 1, one addressing borderline resectable PDAC and one addressing venous involvement. They were combined for the second round of voting based on expert feedback. For statement 10, two separate statements were included in round 1, one addressing locally advanced PDAC and one addressing arterial resection. They were combined for the second round of voting based on expert feedback.

significantly higher burden of postoperative complications relative to elective conversion.[78]

Section 5: Implementation, Training, and Innovation

Finalized statements addressing implementation, training, and innovation are summarized in Table 4. In terms of training requirements for initiation of an MIPS program, the following elements should be included: dedicated team training, simulation and biotissue labs, continuous improvement techniques, video-based coaching, and proctored mentorship during the initial learning curve.[79–83] Implementation of a MIPS program should be restricted to institutions with adequate pancreatic volume.[81,82] Outcomes should be followed to ensure patient safety.[5]

There is currently limited evidence regarding outcomes associated with the use of 3D imaging and augmented reality in pancreatic surgery. Although still limited, there is more evidence supporting the use of 3D imaging relative to augmented reality.[84–87]

Statements not reaching consensus

Statements ultimately eliminated based on expert feedback included those addressing the cost-effectiveness of minimally invasive versus open techniques. Expert panel comments highlighted the difficulty of comparing costs across healthcare systems and countries, as well as the overall lack of high-quality evidence. Similarly, a statement regarding the impact of minimally invasive surgery on quality of life and receipt of adjuvant

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Table 3 Neuroendocrine Pancreatic Tumors

Question and Statement	R1 (%)	R2 (%)
In patients with pancreatic neuroendocrine tumors for whom enucleation is technically feasible, is minimally invasive enucleation comparable to open enucleation? **Statement 14: In patients with pancreatic neuroendocrine tumors amenable to enucleation, minimally invasive enucleation provides outcomes comparable to open enucleation. Optimal patient selection and treatment at high-volume centers that systematically monitor outcomes are essential. Intraoperative ultrasound should be employed to define tumor location and its relationship to the main pancreatic duct, regardless of whether the approach is open or minimally invasive.**	**96**	
In patients undergoing minimally invasive surgery for left-sided pancreatic neuroendocrine tumors, are laparoscopic and robotic approaches comparable? **Statement 15: For patients with pancreatic neuroendocrine tumors (PNETs) of the body or tail, robotic distal pancreatectomy is associated with longer operative time and higher cost, but also with higher rates of splenic preservation, reduced blood loss, and a lower risk of conversion to open surgery compared to the laparoscopic approach, in well-selected patients. Postoperative morbidity and mortality are comparable between approaches.**	**96**	
In patients undergoing minimally invasive surgery for left-sided pancreatectomy where spleen preservation is indicated, are robotic and laparoscopic approaches comparable in terms of both Warshaw and Kimura techniques? **Statement 16: Both robotic and laparoscopic approaches are viable options for minimally invasive spleen-preserving distal pancreatectomy, although the robotic approach may facilitate splenic preservation. The choice between splenic vessel preservation (Kimura technique) and splenic vessel resection with preservation of the short gastric and left gastroepiploic vessels (Warshaw technique) should be individualized based on intraoperative findings, patient-specific factors, and surgeon experience.**	**88**	**100**
In patients with neuroendocrine tumors (NETs) of the pancreatic head, how do minimally invasive approaches compare to open techniques? **Statement 17: For patients with pancreatic neuroendocrine tumors (PNETs) of the head, minimally invasive surgery is generally associated with reduced intraoperative blood loss but longer operative times. Postoperative morbidity, oncologic outcomes, and survival appear comparable across approaches.**	**96**	
In patients with NETs of the pancreatic head, how does LPD compare to RPD? **Statement 18: In patients with pancreatic neuroendocrine tumors (PNETs) of the head, robotic pancreatoduodenectomy (RPD) performed at high-volume centers demonstrates perioperative outcomes comparable to laparoscopic pancreatoduodenectomy (LPD). The choice of approach should be guided by institutional resources and surgeon proficiency (i.e., those who have completed the learning curve).**	**92**	

chemotherapy was discarded as experts felt that the current body of evidence is insufficient to support a definitive conclusion. Finally, the role of intraoperative ultrasound and pancreatoscopy for non-neuroendocrine pancreatic cancer was debated. Some experts indicated that IOUS is an effective adjunct that enhances surgical precision, whereas others noted that the available evidence does not demonstrate a clear benefit. The inability to reach consensus on the roles of intraoperative ultrasound and pancreatoscopy suggests that these are important areas for future investigation.

Discussion

This international consensus offers oncology-focused guidance for minimally invasive pancreatic surgery, developed through a Delphi process. Fifty-two hepatobiliary surgeons from multiple continents participated, ensuring broad representation of practice patterns and health systems.

Previous international guidelines on minimally invasive pancreatic surgery have been published, notably the Miami International Evidence-based Guidelines on Minimally Invasive Pancreas Resection and the Brescia European Guidelines (EGUMIPS).[6,7] The São Paulo consensus is cancer-focused and incorporates evidence from recently published papers, including randomized trials, large multicenter cohorts, and expanded robotic experience. This consensus employs standardized anatomic definitions for distal pancreatectomy (Types 1—4), explicitly distinguishes venous from arterial involvement, and provides specific guidance for chemotherapy settings.[16] It also emphasizes the factors needed to safely develop a minimally invasive pancreas program, including a structured training program. The analysis emphasized comparability and equivalence of surgical methods.

This consensus strongly affirms that minimally invasive pancreatic resections for cancer should be centralized at high-volume institutions. However, institutional volume, while necessary, is insufficient. Surgeon proficiency and cumulative experience are also critical determinants of patient safety and oncologic adequacy. A multicenter training study has proposed practical case-volume thresholds for robotic pancreatoduodenectomy to guide program development: feasibility (∼15 cases) represents the initial stage in which a surgeon can complete the procedure safely; proficiency (∼62 cases) indicates consistent, efficient performance with optimized outcomes; and mastery (∼84 cases) denotes a high level of skill, often with the ability to manage complex variations and teach others.[88] Therefore, procedural volume should be viewed not merely as a metric but as a mechanism to ensure the surgeon's ongoing technical

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Table 4 Patient Evaluation and Surgical Technique; Implementation, Training, and Innovation

Question and Statement	R1 (%)	R2 (%)
In patients with pancreatic cancer undergoing minimally invasive pancreatic resection (MIPR), does the addition of multimodal prehabilitation (compared to standard care) (a) increase the rate of adjuvant therapy administration and (b) improve quality of life? **Statement 19: Multimodal prehabilitation — including exercise, nutritional optimization, psychological support, and management of comorbidities — has been shown to improve cardiorespiratory fitness, muscle mass, nutritional status, and functional capacity in patients undergoing minimally invasive pancreatic resection, including those treated with neoadjuvant therapy.**	**96**	
During minimally invasive pancreatic surgery, under what circumstances should surgeons opt to convert to an open approach to ensure patient safety, maintain oncologic standards, and optimize perioperative results? (Consider both elective and emergency conversions) **Statement 20: During minimally invasive pancreatic resections, conversion to an open approach should be performed when oncologic concerns, vascular involvement that cannot be managed minimally invasively, or intraoperative complications arise. Elective conversion is strongly preferred, as emergent conversion is associated with worse outcomes.**	**96**	
What are the essential prerequisites and training requirements for surgeons initiating and maintaining a MIPR program for cancer, and how should a modern surgical team be structured to ensure proficiency, safety, and optimal oncologic outcomes? **Statement 21: It is strongly recommended that minimally invasive pancreatic resection (MIPR) programs be initiated under proctoring within a structured, stepwise skill-acquisition framework, and only by surgeons already proficient in both open pancreatic surgery and minimally invasive techniques. Training should additionally include simulation laboratory-based work. Implementation should be limited to institutions with adequate pancreatic case volumes, with ongoing outcomes monitoring to ensure patient safety.**	**96**	
In patients undergoing MIPR, how do advanced visualization and navigation technologies, including those enhanced by artificial intelligence, compare to conventional techniques in terms of postoperative and oncological outcomes? **Statement 22: The use of 3D imaging and augmented reality in pancreatic surgery should be adopted based on surgeon preference, as high-quality evidence demonstrating definitive clinical benefit remains limited.**	**94**	

Notes: For statement 19, due to insufficient evidence regarding adjuvant therapy administration and quality of life, the experts were unable to include these outcomes in the finalized statement.

competence. This principle is especially pertinent in complex scenarios, such as pancreatic cancer with vascular involvement, where foundational hepatopancreatobiliary experience alone is inadequate. Structured training, prior experience with minimally invasive surgery, and the use of simulation can help surgeons achieve proficiency more efficiently. The consensus appropriately highlights the importance of structured training, proctoring, simulation-based preparation, stepwise case exposure, and objective assessment of technical skills for establishing a minimally invasive pancreatic resection program.

As robotic platforms continue to diffuse worldwide, there is a parallel need to ensure that adoption is guided by evidence-based standards rather than driven primarily by the availability of technology. In this context, expert centers and professional societies are well-positioned to define training pathways, credentialing criteria, and quality benchmarks for robotic pancreatic surgery. Leadership by experienced HPB teams helps ensure that the expansion of robotic approaches prioritizes patient safety, oncologic rigor, and equitable access—rather than being driven by institutional resources or industry influence.

Furthermore, the consensus highlights additional important center characteristics, including systematic outcomes monitoring, and appropriate resources to manage postoperative complications. In fact, many of the consensus statements indicate that institutions performing minimally invasive pancreatic resections should engage in continuous outcomes monitoring. To ensure rigor and transparency, this evaluation could be conducted by an independent oversight body. Alternatively, data could be reported to and aggregated in regional or national databases. Beyond ensuring accountability, continuous outcomes monitoring provides a data-driven foundation for future decision-making. In England, the Royal College of Surgeons has established a proactive framework to regulate training and credentialing, as well as conduct prospective auditing for robotic-assisted procedures.[89] In the Netherlands, the nationwide, mandatory Dutch Pancreatic Cancer Audit has been collecting data since 2013 on all patients undergoing surgery for pancreatic or periampullary tumors, as mandated by the Dutch Healthcare Inspectorate. Its primary goal is to improve outcomes by reducing unwarranted variation in practice and promoting best practices. The audit is implemented in all 18 pancreatic surgery centers, which must each perform at least 20 pancreatoduodenectomies per year.[90] Similar oversight bodies exist in Japan, including the Japanese Society of Hepato-Biliary-Pancreatic Surgery. In the United States, monitoring is limited to voluntary participation in specialty-specific registries, such as the National Surgical Quality Improvement Program. Country-

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specific resources and healthcare systems will determine the most feasible mechanism for continuous outcomes monitoring. For example, many countries, including Brazil and France, face significant challenges in implementing nationwide data collection and monitoring, due to regional disparities in infrastructure and funding. While pioneering centers may develop internal governance models inspired by international standards, systematic, higher-level oversight remains inconsistent. However, centers and surgeons developing minimally invasive pancreas programs are capable of following their own outcomes and should do so regardless of external resources. A prospectively maintained database allows for a realistic assessment of a surgeon's own results and comparison with the expected outcomes.

Although this consensus does not specifically address it, the patient perspective is an important consideration when selecting between minimally invasive and open approaches. Many patients have a limited understanding of the actual role of the robotic platform.[91] Therefore, counseling should incorporate shared decision-making, ensuring appropriate patient education, clear disclosure of device-specific risks and alignment among clinical evidence, patient values, expectations, and cost considerations, particularly in settings where patients may directly bear the cost of the robotic system.[92]

This work has limitations. Despite broad participation and high agreement thresholds, this consensus reflects expert opinion informed by the best currently available evidence. For many statements, the best available evidence consists of retrospective and observational studies with important methodological limitations. At present, there are limited prospective studies and RCTs addressing minimally invasive pancreas resection. Statements addressing the comparability of open versus minimally invasive techniques should be interpreted with acknowledgement of the limited evidence upon which they are based. Further, the supporting literature often includes mixed tumor types, diluting the evidence base for specific entities like pancreatic adenocarcinoma. As a result, some statements rely on inference and extrapolation. Furthermore, non-randomized data are susceptible to a significant risk of selection bias, as minimally invasive procedures are often offered to patients with more favorable disease characteristics. These recommendations should be revisited and updated over time, as new data emerge, and be viewed both as a resource to guide MIPS adoption, but also as a call to action to generate higher-level evidence on the use of minimally invasive techniques for pancreas surgery. Most data are derived from high-income countries, where surgical infrastructure, resources, and patient care pathways differ significantly from those in many other regions. Consequently, external validity across diverse health systems is imperfect, and the real-world implementation of minimally invasive surgery may yield different outcomes, depending on local infrastructure. Surgeons must therefore adapt the recommendations from this consensus to their local circumstances, particularly in low- and middle-income countries where limited access to essential resources; such as staplers, skilled personnel, intensive care unit beds, and the availability of advanced therapeutic options for managing post-pancreatectomy complications; can substantially influence outcomes and decrease the net benefit of the MIS approach.

Consensus documents carry significant weight, since they may influence policymakers, hospital administrators, and procurement decisions. Consequently, they can inform the adoption of specific technologies, such as robotic platforms or specialized materials for minimally invasive surgery. While technological advancement is a goal, it must be carefully weighed against financial sustainability and broader resources, especially in low- and middle-income countries. In these settings, the fundamental prerequisites for safe surgery, including skilled personnel, intensive care unit beds, and the capability to promptly manage post-pancreatectomy complications, must take precedence. Therefore, surgeons and health systems must critically evaluate the recommendations from this consensus, ensuring that technological adoption does not outpace the establishment of foundational, life-saving surgical capacity.[82] This consensus should not be viewed as strict directives but as guidance within a continuing, international, collaborative effort to evaluate MIPS and guide its responsible adoption. It also highlights clear gaps that warrant further research and development in pancreatic cancer surgery.

Future research should prioritize periodic evidence updates and reappraisal of these recommendations as higher-quality data accrue. In this regard, extended follow-up from existing studies and forthcoming results from ongoing trials—most notably DIPLOMA-2 (currently available as a protocol for an international, multicenter, patient-blinded RCT comparing minimally invasive versus open pancreatoduodenectomy)—will be essential.[93] Continued generation of level 1 evidence will be critical to refine practice guidelines and optimize the safe and effective adoption of minimally invasive pancreas surgery. Analyses must also interrogate regional heterogeneity in outcomes, incorporating case-mix adjustment, perioperative infrastructure, and postoperative care pathways to generate resource-stratified, equity-focused implementation guidance for low- and middle-income settings. Technology assessment should include high-quality evaluations of newer robotic platforms and rigorous, prospective validation of AI-enabled decision support, computer-vision—assisted dissection, and enhanced visualization.

Conclusion

This international consensus, developed through a Delphi process, provides a crucial, evidence-informed framework for minimally invasive pancreatic surgery in cancer care. Moving beyond technical feasibility to emphasize structured training, programmatic requirements, and context-sensitive

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implementation, it outlines a pragmatic pathway for the safe and equitable integration of MIPS into clinical practice. Beyond guiding current surgical practice, this document reflects a collective effort to shape future research and strengthen collaboration within the global surgical community.

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Data sharing

Not applicable.

Conflict of interest

Tustumi received research scholarships from the Bracell Foundation. Polanco serves as a consultant for Medtronic and a proctor for Intuitive Surgical. Luyer received institutional research grants from Galvani and Medtronic. Hewitt is a proctor for Intuitive. Asbun is a consultant for Stryker, Ethicon, and Medtronic and has received honoraria from Intuitive. Hogg has participated in occasional courses with Intuitive. None of these companies had any role in the study design, data collection, analysis, interpretation, manuscript preparation, or the decision to submit this work for publication. All other authors declare no conflicts of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.hpb.2025.11.012.