The Miami International Evidence-Based Guidelines on Minimally Invasive Pancreas Resection

Horacio J. Asbun, MD, FACS,✉ *Alma L. Moekotte, MD,*†‡ *Frederique L. Vissers, MD,*‡ *Filipe Kunzler, MD,** *Federica Cipriani, MD,*§ *Adnan Alseidi, MD, EdM, FACS,*¶ *Michael I. D'Angelica, MD, FACS,*‖ *Alberto Balduzzi, MD,*** *Claudio Bassi, MD, FRCS, FACS,*** *Bergthor Björnsson, MD, PhD,*†† *Ugo Boggi, MD, FEBS,*‡‡ *Mark P. Callery, MD, FACS,*§§ *Marco Del Chiaro, MD, PhD, FACS,*¶¶ *Felipe J. Coimbra, MD,*‖‖ *Claudius Conrad, MD, PhD, FACS,**** *Andrew Cook, MBBS, MPH,*††† *Alessandro Coppola, MD, PhD,*‡‡‡ *Christos Dervenis, MD, PhD, FRCS,*§§§ *Safi Dokmak, MD, PhD,*¶¶¶ *Barish H. Edil, MD, FACS,*‖‖‖ *Bjørn Edwin, MD, PhD,***** *Pier C. Giulianotti, MD,*†††† *Ho-Seong Han, MD, PhD,*‡‡‡‡ *Paul D. Hansen, MD, FACS,*§§§§ *Nicky van der Heijde, MD,*†‡ *Jony van Hilst, MD, MSc, PhD,*‡ *Caitlin A. Hester, MD,*¶¶¶¶ *Melissa E. Hogg, MD, MS,*‖‖‖‖‖‖‖ *Nicolas Jarufe, MD,****** *D. Rohan Jeyarajah, MD, FACS,*††††† *Tobias Keck, MD, MBA, FACS,*‡‡‡‡‡ *Song Cheol Kim, MD, PhD,*§§§§§ *Igor E. Khatkov, MD, PhD,*¶¶¶¶¶ *Norihiro Kokudo, MD, PhD, FACS, FRCS,*‖‖‖‖‖‖‖‖‖ *David A. Kooby, MD, FACS,****** *Maarten Korrel, BSc,*‡ *Francisco J. de Leon, MD,*††††† *Nuria Lluis, MD,*‡‡‡‡‡ *Sanne Lof, MD,*†‡ *Marcel A. Machado, MD, FACS,*§§§§§§ *Nicolas Demartines, MD, FACS, FRCS,*¶¶¶¶¶¶ *John B. Martinie, MD, FACS,*‖‖‖‖‖‖‖‖‖‖ *Nipun B. Merchant, MD, FACS,******* *I. Quintus Molenaar, MD, PhD,*††††††† *Cassadie Moravek, BS,*‡‡‡‡‡‡ *Yi-Ping Mou, MD, FACS,*§§§§§§§ *Masafumi Nakamura, MD, PhD,*¶¶¶¶¶¶¶ *William H. Nealon, MD,*‖‖‖‖‖‖‖‖‖‖‖‖ *Chinnusamy Palanivelu, MD,******** *Patrick Pessaux, MD, PhD,*†††††††† *Henry A. Pitt, MD,*‡‡‡‡‡‡‡ *Patricio M. Polanco, MD,*¶¶¶¶ *John N. Primrose, FMedSci,*† *Arab Rawashdeh, MD,*† *Dominic E. Sanford, MD,*§§§§§§§§ *Palanisamy Senthilnathan, MD,******** *Shailesh V. Shrikhande, MD, FRCS,*¶¶¶¶¶¶¶¶ *John A. Stauffer, MD,*‖‖‖‖‖‖‖‖‖‖‖‖‖ *Kyoichi Takaori, MD, PhD, FACS,********* *Mark S. Talamonti, MD,*‖‖‖‖‖‖‖ *Chung N. Tang, MD, MDDS, FCSHK, FRCS, FHKAM,*††††††††† *Charles M. Vollmer, MD,*‡‡‡‡‡‡‡‡‡ *Go Wakabayashi, MD, PhD, FACS,*§§§§§§§§§ *R. Matthew Walsh, MD, FACS,*¶¶¶¶¶¶¶¶¶ *Shin-E Wang, MD,*‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖‖ *Michael J. Zinner, MD,** *Christopher L. Wolfgang, MD, MSc, PhD, FACS,********** *Amer H. Zureikat, MD, FACS,*†††††††††† *Maurice J. Zwart, MSc,*‡ *Kevin C. Conlon, MD, FRCSI, FACS, FRCSG, FTCD,*‡‡‡‡‡‡‡‡‡‡ *Michael L. Kendrick, MD,*§§§§§§§§§§ *Herbert J. Zeh, MD,*††††††††††† *Mohammad Abu Hilal, MD, PhD, FACS, FRCS,*†¶¶¶¶¶¶¶¶¶¶ *and Marc G. Besselink, MD, PhD*‡*, on behalf of the International Study Group on Minimally Invasive Pancreas Surgery (I-MIPS)*

Objective: The aim of tis study was to develop and externally validate the first evidence-based guidelines on minimally invasive pancreas resection (MIPR) before and during the International Evidence-based Guidelines on Minimally Invasive Pancreas Resection (IG-MIPR) meeting in Miami (March 2019).

Summary Background Data: MIPR has seen rapid development in the past decade. Promising outcomes have been reported by early adopters from high-volume centers. Subsequently, multicenter series as well as randomized controlled trials were reported; however, guidelines for clinical practice were lacking.

Methods: The Scottisch Intercollegiate Guidelines Network (SIGN) methodology was used, incorporating these 4 items: systematic reviews using PubMed, Embase, and Cochrane databases to answer clinical questions, whenever possible in PICO style, the GRADE approach for assessment of

From the *Division of Hepatobiliary and Pancreas Surgery, Miami Cancer Institute, Miami, FL; †Department of Surgery, University Hospital Southampton NHS Foundation Trust, Southampton, UK; ‡Department of Surgery, Amsterdam UMC, University of Amsterdam, Amsterdam, the Netherlands; §Department of Surgery, San Raffaele Hospital, Milan, Italy; ¶Division of Hepatopancreatobiliary and Endocrine Surgery, Virginia Mason Medical Center, Seattle, VA; ||Department of Surgery, Memorial Sloan Kettering Cancer Center, New York City, NY; **Division of Pancreatic Surgery, University Hospital of Verona, Verona, Italy; ††Department of Surgery and Department of Clinical and Experimental Medicine, Linköping University, Linköping, Sweden; ‡‡Division of General and Transplant Surgery, University of Pisa, Pisa, Italy; §§Department of General and Gastrointestinal Surgery, Beth Israel Deaconess Medical Center, Boston, MA

the quality of evidence, the Delphi method for establishing consensus on the developed recommendations, and the AGREE-II instrument for the assessment of guideline quality and external validation. The current guidelines are cosponsored by the International Hepato-Pancreato-Biliary Association, the Americas Hepato-Pancreato-Biliary Association, the Asian-Pacific Hepato-Pancreato-Biliary Association, the European-African Hepato-Pancreato-Biliary Association, the European Association for Endoscopic Surgery, Pancreas Club, the Society of American gastrointestinal and Endoscopic Surgery, and the Society for Surgery of the Alimentary.

Results: After screening 16,069 titles, 694 studies were reviewed, and 291 were included. The final 28 recommendations covered 6 topics; laparoscopic and robotic distal pancreatectomy, central pancreatectomy, pancreatoduodenectomy, as well as patient selection, training, learning curve, and minimal annual center volume required to obtain optimal outcomes and patient safety.

Conclusion: These IG-MIPR using SIGN methodology give guidance to surgeons, hospital administrators, patients, and medical societies on the use and outcome of MIPR as well as the approach to be taken regarding this challenging type of surgery.

Keywords: central pancreatectomy, distal pancreatectomy, guidelines, implementation, laparoscopic, left pancreatectomy, minimally invasive, pancreatoduodenectomy, robot, robot assisted, robotic, techniques, training, Whipple

(*Ann Surg* 2019;xx:xxx–xxx)

Minimally invasive pancreas resection (MIPR) comprises both laparoscopic and robotic pancreatic surgery. MIPR has seen rapid development in the last decade. Initially, early adopters from a few high-volume centers performed these procedures and reported promising outcomes.[1–8] Thereafter, multicenter series,[9–13] and even the first (monocenter and multicenter) randomized controlled trials[14–17] were published and training programs were developed.[18–20] However, evidence-based guidelines for this field are still lacking. Evidence-based guidelines would not answer all relevant questions, but they should use a methodology to answer PICO-style questions and provide recommendations. The methodology used in this project employs the Scottisch Intercollegiate Guidelines Network (SIGN), which incorporates the rigorous GRADE methodology on literature reviews and assign a score of the quality of evidence and strength of recommendations. SIGN is accredited by NICE (The National Institute for Health and Care Excellence).

The first International State-of-the-Art update meeting on MIPR was organized in São Paulo, during the IHPBA 2016 World Congress and was cosponsored with AHPBA. In the March 2017 issue of HPB, several articles reported the proceedings of this meeting.[21–29]

The present evidence-based guidelines build on that experience. It does not try to repeat several of the topics already adequately addressed in São Paulo but delve into areas of controversy with additional evidence. The current guidelines are cosponsored by multiple international surgical societies and contains evidence on both laparoscopic (LDP) and robotic distal pancreatectomy (RDP), central pancreatectomy, pancreatoduodenectomy, as well as patient selection, training, learning curve, and minimal annual center volume to obtain optimal outcomes and patient safety.

METHODS

The present evidence-based guideline is a joint initiative of the International Hepato-Pancreato-Biliary Association (IHBPA), the Americas Hepato-Pancreato-Biliary Association (AHPBA), the

¶¶Department of Surgery, Division of Surgical Oncology, University of Colorado, Denver, CO; ||||Department of Abdominal Surgery, AC Camargo Cancer Center, São Paulo, Brazil; **Department of Surgery, St. Elizabeth's Medical Center, Boston, MA; †††Wessex Institute, University of Southampton, UK; ‡‡‡General Surgery and Liver Transplant, Unit Department of General Surgery, Fondazione Policlinico, Universitario Agostino Gemelli, IRCCS, Rome, Italy; §§§Department of Surgery, Medical School, University of Cyprus, Cyprus; ¶¶¶Department of Surgery, Beaujon Hospital, Paris, France; ||||||Department of Surgery, University of Oklahoma, Oklahoma City, OK; ****The Intervention Centre and Department of HPB Surgery, Oslo University Hospital and Institute of Clinical Medicine, Faculty of Medicine, University of Oslo, Oslo, Norway; ††††Division of Minimally Invasive, General Surgery & Robotic Surgery, University of Illinois, Chicago, IL; ‡‡‡‡Department of Surgery, Seoul National University Hospital, Seoul, South Korea; §§§§Department of Surgery, Portland Providence Medical Center, Portland, OR; ¶¶¶¶Department of Surgery, University of Texas Southwestern Medical Center, Dallas, TX; ||||||||Department of Surgery, NorthShore University Health System, Evanston, IL; *****Department of Digestive Surgery, Pontifical Catholic University of Chile, Santiago, Chile; †††††Department of HPB surgery, Methodist Richardson Medical Center, Richardson, TX; ‡‡‡‡‡Clinic for Surgery, University of Schleswig-Holstein Campus Lübeck, Lübeck, Germany; §§§§§Department of Surgery, Ulsan University College of Medicine and Asan Medical Center, Seoul, South Korea; ¶¶¶¶¶Department of Surgery, Moscow Clinical Scientific Center, Moscow, Russia; |||||||||Department of Surgery, National Center for Global Health and Medicine, Tokyo, Japan; ******Department of Surgery, Winship Cancer Institute, Emory University, Atlanta, GA; ††††††HPB and transplant Unit, Regional Hospital, Málaga, Spain; ‡‡‡‡‡‡Department of Surgery, Bellvitge University Hospital, Barcelona, Spain; §§§§§§Department of Surgery, University of São Paulo, São Paulo, Brazil; ¶¶¶¶¶¶Department of Visceral Surgery, Lausanne University Hospital CHUV, Lausanne, Switzerland; ||||||||||Division of HPB Surgery, Department of Surgery, Carolina's Health Care Hospital, Charlotte, NC; *******Division of Surgical Oncology, Department of Surgery, University of Miami Miller School of Medicine, Miami, FL; †††††††Department of Surgery, UMC Utrecht Cancer Center, University Medical Center Utrecht, Utrecht, the Netherlands; ‡‡‡‡‡‡‡Pancreatic Cancer Action Network, Manhattan Beach, CA; §§§§§§§Department of Gastroenterology and Pancreatic surgery, Zhengjiang Provincial People's Hospital, People's Hospital of Hangzhou Medical College, Zhejiang, China; ¶¶¶¶¶¶¶Department of Surgery and Oncology, Graduate School of Medical Sciences, Kyushu University, Fukuoka, Japan; ||||||||||||Department of Surgery, Northwell Health, Manhasset, NY; ********Department of Surgical Gastroenterology and HPB Surgery, GEM Hospital and Research Centre, Coimbatore, Tamil Nadu, India; ††††††††Division of Hepato-Biliary and Pancreatic Surgery, Nouvel Hôpital Civil, Institut Hospitalo-Universitaire de Strasbourg, Strasbourg, France; ‡‡‡‡‡‡‡‡Department of Surgery, Lewis Katz School of Medicine at Temple University, Philadelphia, PA; §§§§§§§§Division of Hepatobiliary, Pancreatic, and Gastrointestinal Surgery, Barnes-Jewish Hospital and the Alvin J. Siteman Cancer Center, Washington University School of Medicine, St. Louis, MO; ¶¶¶¶¶¶¶¶Department of Surgery, Tata Memorial Center, Mumbai, India; ||||||||||||||Department of General Surgery, Mayo Clinic Florida, Jacksonville, FL; *********Department of Surgery, Kyoto University Graduate School of Medicine, Kyoto, Japan; †††††††††Department of Surgery, Pamela Youde Nethersle Eastern Hospital, Chai Wan, Hong Kong, China; ‡‡‡‡‡‡‡‡‡Department of Surgery, University of Pennsylvania Perelman School of Medicine, Philadelphia, PA; §§§§§§§§§Center for Advanced Treatment of HPB Diseases, Ageo Central General Hospital, Saitama, Japan; ¶¶¶¶¶¶¶¶¶Department of General Surgery, Cleveland Clinic, Cleveland, OH; ||||||||||||||||Department of Surgery, Taipei Veterans General Hospital and National Yang Ming University, Taipei, Taiwan; **********Division of Surgical Oncology, Department of Surgery, The John Hopkins University School of Medicine, Baltimore, MD; ††††††††††Division of Surgical Oncology, Department of Surgery, University of Pittsburgh School of Medicine, Pittsburgh, PA; ‡‡‡‡‡‡‡‡‡‡Department of Surgery, Trinity College Dublin, Tallaght University Hospital, Dublin, Ireland; §§§§§§§§§§Department of Surgery, Mayo Clinic, Rochester, Minnesota, MN; and ¶¶¶¶¶¶¶¶¶¶Department of Surgery, Istituto Fondazione Poliambulanza, Brescia, Italy.

✉horacio@asbunsurgery.org.

A.L.M. and F.L.V. shared second author.

M.A.H. and M.G.B. shared senior author

The authors report no conflicts of interest.

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's Web site (www.annalsofsurgery.com).

ISSN: 0003-4932/16/XXXX-0002

DOI: 10.1097/SLA.0000000000003590

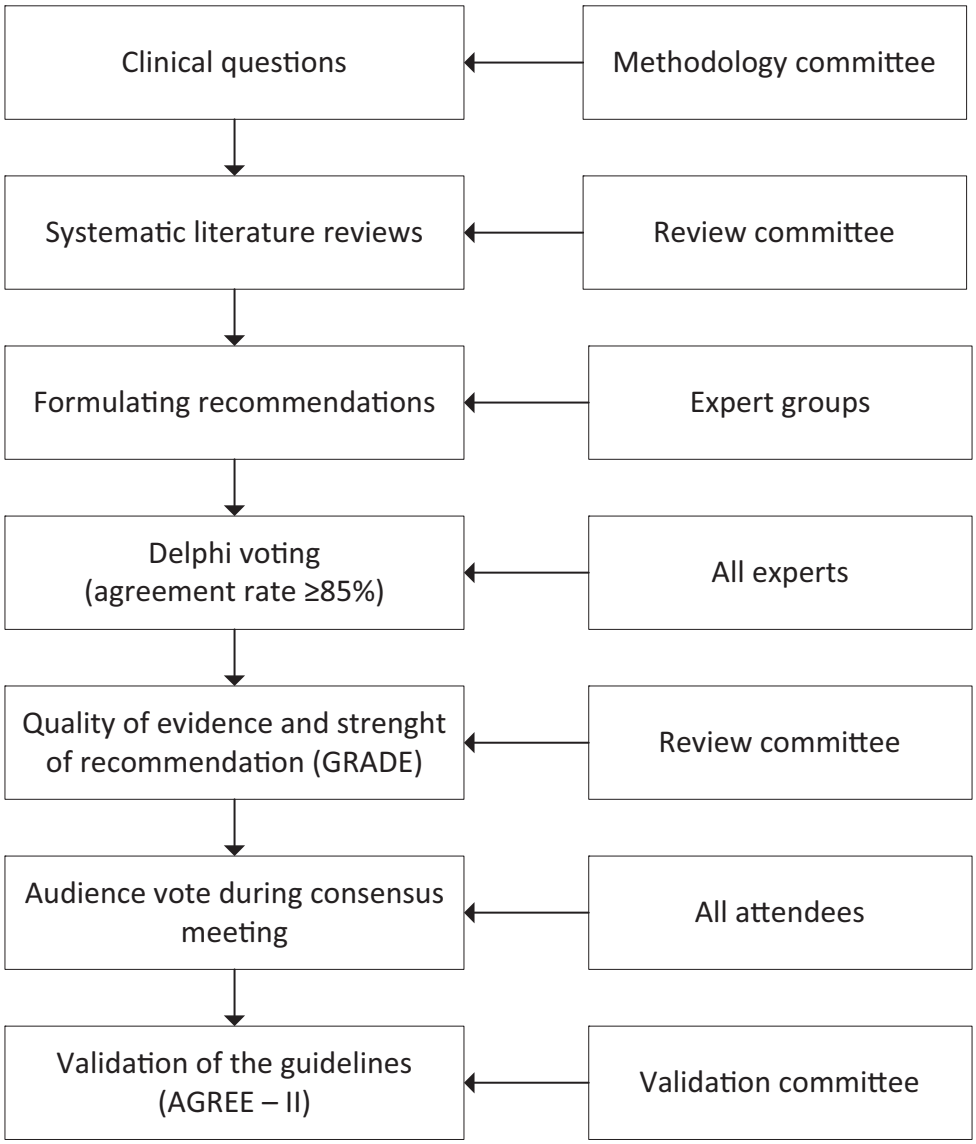

FIGURE 1. Flow chart of the guideline process.

Asian-Pacific Hepato-Pancreato-Biliary Association (A-PHPBA), the European-African Hepato-Pancreato-Biliary Association (E-AHPBA), the Pancreas Club, the Society of American gastrointestinal and Endoscopic Surgery (SAGES), the European Association for Endoscopic Surgery (EAES), and the Society for Surgery of the Alimentary (SSAT) and involves international experts (Supplementary Tables S1–S5, http://links.lww.com/SLA/B781).

The process and steps taken to reach the final recommendations are represented in Figure 1. A methodology committee identified the most important clinical questions, which were approved by the steering committee, and assigned expert review groups to evaluate each of these questions. Each group consisted of 2 to 5 MD/PhD students who performed systematic literature reviews and 5 to 8 experts in the field (Fig. 2). In October 2018, each group received a list of questions regarding their topic. The groups were encouraged to suggest changes and/or add relevant questions based on their expertise and available literature. Furthermore, all members of the expert review groups were asked to take a tutorial on the SIGN method,[30] which incorporates the GRADE methodology.[31]

Once all questions were finalized by each group, the following steps were made to provide evidence-based recommendations and remarks:

(a) Literature review: A systematic literature review was performed using PubMed, Embase, and Cochrane databases to include randomized trials, observational cohort studies, and systematic reviews with a minimum of 20 patients undergoing a MIPR published in English, and available in full text. SIGN methodology[30] was used to assess the quality of the evidence.
(b) Summary of studies: A summary of each reviewed manuscript was completed, and a brief summary of the literature along with

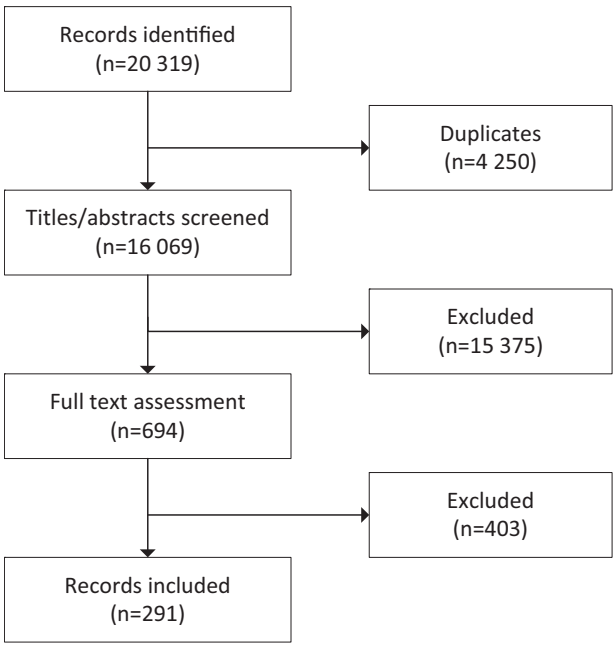

FIGURE 2. Flow chart of systematic literature review.

evidence tables were created for each question, aggregating the studies to facilitate answering the questions.

(c) Recommendations: Recommendations were formulated based on the available evidence. All recommendations included a GRADE rating[31] (see Tables 1 and 2) based on the quality of evidence and strength of recommendation.

(d) Remarks: When deemed necessary, relevant remarks to enhance the recommendations were added.

(e) Proposed actions: Given that there was insufficient literature for several of the recommendations, a proposed future action is formulated to emphasize research opportunities and improve the quality of evidence.

Each group submitted the above listed items (a–d) per question to the steering committee before December 31st, 2018. A synthesis of the work from different groups was completed in January 2019 by the chairs of the steering and methodology committee (H.A., M.G.B., and M.A.H.). The synthesis of the work was then distributed to all experts, for a first Delphi vote. The results of the Delphi vote were kept anonymous and reviewed by the chair (H.A.) who did not participate in the Delphi vote. Recommendations were approved if an agreement rate of $\geq$85% was achieved. If the predefined rate of 85% was not reached, the recommendation, including feedback comments, was returned to the expert review group to amend accordingly. Subsequently, the amended recommendations that had not passed on the first Delphi round were sent to all experts for a second Delphi vote. The same approval process was followed. In the event that a recommendation would not pass the second Delphi round, plans were to go through a third Delphi on site at the International Evidence-based Guidelines on Minimally Invasive Pancreas Resection (IG-MIPR) meeting. On March 18 and 19, 2019, the evidence-based recommendations were presented and discussed during the IG-MIPR meeting in Miami Beach. Two additional processes took place during the meeting:

(a) AGREE II: A validation committee used the AGREE II instrument[32] to assess the quality of the guidelines. This committee consisted of 18 members that included open, laparoscopic, and robotic experts as well as administrators, a patient advocate representative, a methodologist, and a facilitator with prior experience on the process. To avoid bias, the committee members did not participate in the creation and had no prior knowledge of the guidelines. After attending each guideline presentation, they had private deliberations for a total of about

TABLE 1. GRADE Recommendations

Quality of evidence	1. Strong Recommendation	2. Weak Recommendation
A. High quality of evidence	1A. Benefits clearly outweigh risk and burdens, or vice versa	2A. Benefits closely balanced with risks and burdens
B. Moderate quality of evidence	1B. Benefits clearly outweigh risk and burdens, or vice versa	2B. Benefits closely balanced with risks and burdens, some uncertainty in the estimates of benefits, risks, and burdens
C. Low quality of evidence	1C. Benefits appear to outweigh risk and burdens, or vice versa	2C. Uncertainty in the estimates of benefits, risks, and burdens; benefits may be closely balanced with risks and burdens

Adapted with permission From: Grading Tutorial.[31] In: UpToDate, Post TW (Ed), UpToDate, Waltham, MA. (Accessed on May 1st, 2019.) Copyright 2019 UpToDate, Inc. For more information, visit www.uptodate.com.

TABLE 2. Quality of Evidence in GRADE

A. High quality of evidence	Consistent evidence from well-performed randomized, controlled trials or overwhelming evidence of some other form. Further research is unlikely to change our confidence in the estimate of benefit and risk.
B. Moderate quality of evidence	Evidence from randomized, controlled trials with important limitations (inconsistent results, methodologic flaws, indirect or imprecise), or very strong evidence of some other form. Further research (if performed) is likely to have an impact on our confidence in the estimate of benefit and risk and may change the estimate.
C. Low quality of evidence	Evidence from observational studies, unsystematic clinical experience, or from randomized, controlled trials with serious flaws. Any estimate of effect is uncertain.

Adapted with permission From: Grading Tutorial.[31] In: UpToDate, Post TW (Ed), UpToDate, Waltham, MA. (Accessed on May 1st, 2019.) Copyright © 2019 UpToDate, Inc. For more information, visit www.uptodate.com.

6.5 hours throughout the meeting, using the AGREE methodology for each guideline statement.

(b) All attendees were surveyed during the meeting about their agreement with the final recommendations via a web-based system. The results of this survey were added to the evidence-based recommendation to provide readers with insight into the level of support among attendees.

Thereafter, in April and May 2019, a combined document with all recommendations was created, which was circulated and approved by all the group leaders and finalized. In June 2019, the final draft of the manuscript containing the recommendations was reviewed and approved by all members of the steering expert, validation, and review committees before submitting the manuscript for publication.

RESULTS

The 6 main topics (A-F) are presented consecutively, incorporating 28 clinical questions (Q1–Q28) and their corresponding recommendations (Table 3). Each recommendation includes a GRADE (level of evidence and strength of recommendation), the expert agreement rate, the overall quality score of the validation committee according to AGREE-II, the IG-MIPR meeting audience agreement rate, and remarks, if appropriate. Agreement rates and quality scores given by the validation committee are expressed as medians with range in Supplementary Figure S1, http://links.lww.com/SLA/B781. The IG-MIPR meeting was attended by 117 surgeons from >20 countries.

Distal and Central Pancreatectomy

Q1. Should Minimally Invasive Distal Pancreatectomy Versus Open Distal Pancreatectomy Be Used Regardless of Indication, When Appropriate?

Recommendation. Q1a: Minimally invasive distal pancreatectomy (MIDP) for benign and low-grade malignant tumors is to be considered over open distal pancreatectomy (ODP), since it is associated with a shorter hospital stay, reduced blood loss, and equivalent complication rates (GRADE 1B, expert agreement 95.0%, quality score 85.0%, audience agreement 100.0%). Q1b: Prospective data about the cost effectiveness of MIDP compared to ODP are limited and require further studies (GRADE 2C, expert agreement 97.5%, quality score 85.0%, audience agreement 91.0%). Q1c: MIDP is associated with a better postoperative quality of life (QoL) than ODP (GRADE 2B, expert agreement 85.0%, quality score 85.0%, audience agreement 88.0%).

Comments. One multicenter randomized controlled trial (RCT) comparing MIDP with ODP reported a shorter hospital stay and reduced blood loss after MIDP, whereas the overall complication rate was similar,[14] hereby confirming the findings of 10 systematic reviews and meta-analyses.[33–42] Cost-effectiveness of LDP compared to ODP was reported in 2 studies and showed a similar or slightly decreased total hospital cost after LDP.[43,44] The RCT and 1 case–control study showed a higher QoL during the first 30 days following MIDP.[14,45] Results from three ongoing RCTs, the multicenter DIPLOMA trial (ISRCTN44897265), the monocenter LAPOP trial (ISRCTN26912858), and the multicenter ''Study of Laparoscopic Versus Open Distal Pancreatectomy in Patients With Pancreatic Cancer at the Body and Tail'' (NCT03792932), should increase the level of evidence available on this topic

Proposed Action. Prospective trials and registries should be designed to evaluate cost and QOL outcomes. Participation in these trials is recommended.

Q2. Should MIDP Versus ODP Be Used for the Treatment of Pancreatic Ductal Adenocarcinoma?

Recommendation. MIDP for pancreatic ductal adenocarcinoma appears to be a feasible, safe, and oncologically equivalent technique in experienced hands, although prospective comparative studies are lacking (GRADE 2B, expert agreement 95.0%, quality score 87.0%, audience agreement 96.0%).

Comments. Three systematic reviews and meta-analyses suggested comparable oncological outcomes in terms of resection margin, 30-day mortality, disease-free survival, and overall survival between MIDP and ODP.[37,46,47] One meta-analysis found a lower lymph node yield during MIDP,[47] whereas another meta-analysis found a similar lymph node yield in both approaches.[37] Results from the DIPLOMA trial and the ''Study of Laparoscopic Versus Open Distal Pancreatectomy in Patients with Pancreatic Cancer at the Body and Tail'' should increase the level of evidence available on this topic.

Proposed Action. Additional randomized trials, with special emphasis on oncological outcomes, should be designed and conducted to increase the level of evidence.

Q3. Should MIDP Versus ODP Be Used for the Treatment of Left-Sided Pancreatic Adenocarcinoma With Vascular Resection?

Recommendation. No evidence exists regarding the use of vascular resection in MIDP. To address this question, data on patient treatment and outcomes need to be entered in prospective registries and databases (EXPERT OPINION, expert agreement 97.5%, quality score 87.0%, audience agreement 98.0%).

Comments. No literature addressing this topic was identified.

Proposed Action. Participation in retrospective and/or prospectively maintained database studies and registries is recommended.

Q4a. Should Staple Versus Another Type of Closure Be Used for Stump Closure in MIDP?

Recommendation. Both stapler and nonstapler closure can be used in MIDP, as outcomes are comparable (GRADE 1C, upgraded from 2C, expert agreement 100.0%, quality score 82.0%, audience agreement 86.0%).

Comments. Several studies reported the safety and feasibility of staple closure in single arm-series[48,49]or noncomparative series between ODP and MIDP.[50,51] Gradual compression stepwise closure should be encouraged.[52]

Proposed Action. Additional randomized trials are to be considered to address the outcomes and cost of stump closure methods.

Q4b. Should Staple Line Reinforcement Versus no Reinforcement Be Used for Stump Closure in MIDP When a Stapler Is Used?

Recommendation. Evidence to support routine staple line reinforcement with any method or material is lacking (GRADE 2C, expert agreement 97.5%, quality score 82.0%, audience agreement 82.0%).

Comments. Data supporting the use of staple line reinforcement specific for MIDP are lacking. Two RCTs concerning the efficiency of Absorbable Fibrin Sealant Patch did not find a significant effect of the patch on the postoperative pancreatic fistula (POPF) rate, but MIDP and ODP were not separated.[53,54] One retrospective study on MIDP found no differences in POPF rate between the group who received TachoSil and those who did not received the surgical patch.[55] Mesh reinforcement was suggested by 1 RCT to reduce the pancreatic fistula rate, but data on MIDP and ODP were not separated.[56]

TABLE 3. Summary of Recommendations

		GRADE
Distal and Central Pancreatectomy		
1a	MIDP for benign and low-grade malignant tumors is to be considered over ODP since it is associated with a shorter hospital stay, reduced blood loss, and equivalent complication rates.	1B
1b	Prospective data about the cost effectiveness of MIDP compared to ODP is limited and requires further studies.	2C
1c	MIDP is associated with a better postoperative quality of life than ODP.	2B
2	MIDP for pancreatic ductal adenocarcinoma appears to be a feasible, safe, and oncologically efficient technique in experienced hands, although prospective comparative studies are lacking.	2B
3	There is no evidence regarding the use of vascular resection in MIDP. To address this question data on patients' treatment and outcomes need to be entered in prospective registries and databases.	Expert opinion
4a	Both stapler and nonstapler closure can be used in MIDP as outcomes are comparable.	2C
4b	Evidence to support routine staple line reinforcement with any method or material is lacking.	2C
5	No studies exist specifically comparing minimally invasive spleen-preserving distal pancreatectomy with open spleen-preserving distal pancreatectomy.	2C
6	Both laparoscopic and robotic distal pancreatectomy are safe and feasible options. The use of either technique should be based on surgeons' experience and local resources.	2B
7a	The feasibility of minimally invasive central pancreatectomy has been reported, but the safety needs to be confirmed before promoting its wide adoption. Studies comparing minimally invasive versus open central pancreatectomy are inadequate in quality and quantity.	1C
7b	Minimally invasive enucleation of pancreatic lesions in selected patients is an appropriate alternative to open enucleation.	2B
Pancreatoduodenectomy		
8	There is insufficient data to recommend MIPD over OPD. Centers performing MIPD should be including all their MIPD outcomes data into national and international registries, and prospectively maintained pancreas database.	2A
9	Both MIPD and OPD are valid approaches for selected patients with adenocarcinoma.	2B
10	No comparative data regarding MIPD vs OPD after neoadjuvant therapy exists and further investigation is warranted.	Expert opinion
11	Limited comparative data regarding vascular resection in MIPD vs OPD exist and further investigation is warranted. MIPD with vascular resection should only be performed by highly experienced surgeons and in high-volume centers.	1C
12	No evidence of superiority between LPD and RPD exists. Surgeon training, experience, and available resources currently guide which approach is utilized.	2C
Patients and technique		
13	There are no contraindications for MIPR based on patient age, obesity or previous abdominal surgery.	1C
14	The evidence to suggest a relationship between comorbidity and the outcome of MIPR is limited in quality and quantity.	2C
15	No evidence exists which specifically addresses the relative benefits of any particular hemostatic technique in MIPR	1C
16	No evidence exists to clearly determine the appropriate timing or indication for conversion in MIPR. Elective conversion should be considered based on surgeon experience, concern for patient safety or failure to progress. The surgeon is expected to have expertise in various methods to control bleeding in the event of hemorrhage that may require urgent conversion	1C
Implementation and training		
17	The value of formal MIPR training is the safe introduction and expansion of MIPR. Participation in a structured training program is strongly recommended for all surgeons undertaking MIPR. A structured MIPR training program may include virtual reality simulation, inanimate biotissue models to practice dissection and anastomotic techniques, surgical video review, on-site proctoring, and remote tele-mentorship.	1C
18	The annual individual surgeon's volume affects individual surgeon's outcomes. Single surgeon learning curves for MIPR show improvements in operative time, blood loss, lymph node harvest and complications with increased total volume/experience; however, the exact number remains to be defined.	2C
19	No specific studies assess prerequisites for MIPR. Experience in pancreatic surgery, including a formal fellowship training or an established practice as a pancreatic surgeon, is advised. A two-surgeon approach can be beneficial in the learning curve, although comparative evidence is lacking	1C
20	Center volume strongly affects outcomes after MIPR and consideration of total pancreas resection volume along with MIPR-specific volume is critical. MIPD should be performed in high-volume centers since mortality (centers <10 MIPD/year) and morbidity (centers <20 MIPD/year) are worse when performed in a low-volume setting.	1B
21	No specific evidence exists on requirements for an MIPR program. However, centers undertaking MIPR should consider including the following components: implementation of dedicated individual and team training, having >1 surgeon performing MIPR at the Institution, monitoring outcomes of MIPR for quality assurance, consideration of surgeon/institution volume of pancreas resections including MIPR	2C

TABLE 3. (*Continued*)

		GRADE
Instrumentation		
22	No documented advantages for any specific energy device have been reported.	Expert opinion
23	The development of instruments and enhanced visualization systems for MIPR should be encouraged.	Expert opinion
Accountability		
24	There are currently several registries for MIPR in development. The inclusion of patient data into thoughtfully organized and maintained regional, national and international registries supported by Hepato-Pancreato-Biliary organizations is strongly encouraged to follow trends and outcomes, and to assess quality.	Expert opinion
25	Outcome monitoring of MIPD is essential for its safe and wide expansion. Inclusion into validated regional, national and international registries is highly recommended.	Expert opinion
26	The development and the expansion of MIPR should be encouraged and monitored by national and international societies through the promotion of specific working groups who will drive training and registries to ensure patient safety and quality improvement.	Expert opinion

Proposed Action. In addition to the action plan for question Q4a, future randomized trials should assess staple line reinforcement and type of stapler.

Q5. Should Minimally Invasive Spleen-Preserving Distal Pancreatectomy Versus Open Spleen-Preserving Distal Pancreatectomy Be Used?

Recommendation. No studies exist specifically comparing minimally invasive spleen-preserving distal pancreatectomy with open spleen-preserving distal pancreatectomy (GRADE 2C, expert agreement 100.0%, quality score 90.0%, audience agreement 98.0%).

Comments. No literature addressing this topic was identified.

Proposed Action. Prospective database studies and registries should compare minimally invasive and open spleen-preserving distal pancreatectomy.

Q6. Should LDP Versus RDP Be Used for the Treatment of Left-Sided Pancreatic Lesions?

Recommendation. Both laparoscopic and robotic distal pancreatectomy are safe and feasible options. The use of either technique should be based on surgeons' experience and local resources (GRADE 1B, upgraded from 2B, expert agreement 100.0%, quality score 83.0%, audience agreement 96.0%).

Comments. Four meta-analyses and 1 propensity score-matched study suggested comparable surgical outcomes between laparoscopic and robotic distal pancreatectomy in terms of POPF rate[57–61] and overall morbidity.[57–59,62] Spleen-preservation rates might be higher during robotic pancreatectomy[57,58,60] or at least similar.[59,61] The oncological outcomes are not different between these modalities.[58,63,64]

Proposed Action. A randomized trial comparing LDP with RDP should be iniatiated, with special consideration to intraoperative complications, spleen preservation, and cost analysis.

Q7a. Should Minimally Invasive Central Pancreatectomy Versus Open Central Pancreatectomy Be Used?

Recommendation. The feasibility of minimally invasive central pancreatectomy has been reported, but the safety needs to be confirmed before promoting its wide adoption. Studies comparing minimally invasive versus open central pancreatectomy are inadequate in quality and quantity (GRADE 1C upgraded from 2C, expert agreement 97.5%, quality score 84.0%, audience agreement 85.0%).

Comments. One cohort study compared minimally invasive to open central pancreatectomy and found a comparable complication rate with a shorter hospital stay in the minimally invasive group.[65] When comparing minimally invasive central pancreatectomy with laparoscopic extended distal pancreatectomy, the complication rate was higher, but the rate of new-onset diabetes mellitus was lower. A single-arm study reported an overall POPF rate of 51.0% after laparoscopic central pancreatectomy.[66]

Proposed Action. Prospective database studies and registries should be employed to improve the quality of evidence on this topic.

Q7b. Should Minimally Invasive Enucleation Versus Open Enucleation of Pancreatic Lesions Be Used?

Recommendation. Minimally invasive enucleation of pancreatic lesions in selected patients is an appropriate alternative to open enucleation (GRADE 2B, expert agreement 97.5%, quality score 84.0%, audience agreement 92.0%).

Comments. Two meta-analyses compared minimally invasive with open enucleation and reported a shorter operative time, a shorter hospital stay, and comparable morbidity for the minimally invasive approach.[67,68] Open enucleation was mainly chosen for deep or posterior lesions,[69] larger or multiple tumors,[70] or expected malignancy.[70,71]

Proposed Action. Prospective database studies and registries are encouraged to improve the level of evidence on this topic.

Pancreatoduodenectomy

Q8. Should Minimally Invasive Pancreatoduodenectomy Versus Open Pancreatoduodenectomy Be Used Regardless of Indication, When Appropriate?

Recommendation. Insufficient data exist to recommend minimally invasive pancreatoduodenectomy (MIPD) over open pancreatoduodenectomy (OPD). Centers performing MIPD should be including all of their MIPD outcomes data into national and international registries, and prospectively maintained databases (GRADE 2A, expert agreement 90.0%, quality score 39.0%, audience agreement 92.0%).

Comments. Three RCTs comparing LPD to OPD have been published.[15–17] Two single-center RCTs reported a shorter hospital stay in LPD.[16,17] The 1 multicenter RCT showed no difference in outcomes but was prematurely stopped because of safety concerns as a result of higher 90-day mortality in the LPD group ($P = 0.2$).[15] In this trial, the major complication (Clavien-Dindo ≥ 3) rate was comparable between the 2 approaches.[15] LPD was found to have a longer operative time. Short-term outcomes, mortality rates, overall costs, 30-day, and 90-day morbidity seem similar between MIPD and

OPD.[5,6,12,13,15–17,72–111] Literature suggests MIPD should be limited to experienced surgeons in high-volume centers because of the long learning curve and the difficulty of the procedure.[5,13,72,90,104,105]

Proposed Action. Surgical societies should mandate centers performing MIPD and/or OPD to maintain a prospective database. To facilitate comparative analysis, additional randomized trials comparing MIPD and RPD, to OPD are encouraged. Trials should be performed only in centers where the MIPD learning curve has been completed.

Q9. Should MIPD Versus OPD Be Used for the Treatment of Periampullary Adenocarcinoma and Pancreatic Ductal Adenocarcinoma?

Recommendation. Both MIPD and OPD are valid approaches for selected patients with adenocarcinoma (GRADE 2B, expert agreement 92.5%, quality score 59.0%, audience agreement 91.0%).

Comments. Oncological outcomes are similar for the 2 approaches.[78,80,89,98,99,104] No difference has been observed in overall survival, 30- and 90-day mortality.[78,84,95] In 1 series, the progression-free survival was reported to be longer in MIPD.[78]

Proposed Action. As per Q8.

Q10. Should MIPD Versus OPD Be Used for the Treatment of Pancreatic Head Adenocarcinoma After Neoadjuvant Therapy?

Recommendation. No comparative data exist, and further investigation is warranted (Expert Opinion, downgraded from 2C, expert agreement 100.0%, quality score 30.0%, audience agreement 87.0%).

Comments. No literature addressing this topic was identified.

Proposed Action. Centers with prospectively maintained databases that have experience with post-neoadjuvant MIPD are encouraged to address this question.

Q11. Should MIPD Versus OPD Be Used for the Treatment of Pancreatic Head Ductal Adenocarcinoma Requiring Vascular Resection?

Recommendation. Limited comparative data exist, and further investigation is warranted. MIPD with vascular resection should only be performed by highly experienced surgeons and in high volume centers (GRADE 1C, upgraded from 2C, expert agreement 95.0%, quality score 41.0%, audience agreement 93.0%)

Comments. A retrospective cohort study reported comparable major complication rates after LPD and OPD with major vascular resection. However, in the OPD group, a higher proportion of complex segmental resections and repairs was performed compared with LPD.[79]

Proposed Action. Centers with prospectively maintained databases that have experience with MIPD vascular resections are encouraged to address this question. Special attention should be given to late complications related to anastomosis quality, such as thrombosis and need for reintervention.

Q12. Should LPD Versus RPD Be Used for the Treatment of Pancreatic Head Lesions?

Recommendation. No evidence of superiority between LPD and RPD exists. Surgeon training, experience, and available resources currently guide which approach is utilized (GRADE 2C, expert agreement 95.0%, quality score 70.0%, audience agreement 98.0%).

Comments. Adequate comparisons of outcomes for LPD and RPD are limited in quantity and quality. Overall perioperative and short-term oncological outcomes are comparable with small, inconsistent differences reported between studies.[91,112–115]

Proposed Action. Randomized controlled trials comparing LPD with RPD are to be considered in high-volume centers by surgeons beyond the learning curve for each approach.

Patients and Technique

Q13. Are There Contraindications for MIPR, Related to Patient Age, obesity, or Complex Previous Abdominal Operations?

Recommendation. There are no contraindications for MIPR based on patient age, obesity, or previous abdominal surgery (GRADE 1C, upgraded from 2C, expert agreement 97.5%, quality score 70.0%, audience agreement 98.0%).

Remark. Visceral obesity and major abdominal surgery may increase operative time, surgical difficulty, and conversion rate. Relative contraindications do exist based on surgeon experience, comfort, center volume, and experience as well as intraoperative findings (eg, pancreatitis, high-risk pancreas) and events. These relative contraindications are especially relevant in the early experience of MIPR and in low-volume centers with less experience in pancreatic surgery.

Comments. In elderly patients, outcomes between MIPR and the open approaches are comparable.[103,110,116–118] When comparing obese patients with normal weight patients undergoing LDP, obese patients had an increased operative time and blood loss, whereas POPF and major complication rates were comparable.[119] When comparing RPD vsersus OPD in obese patients, those undergoing RPD had a shorter operative time, less estimated blood loss, and a lower POPF rate.[83] In a case-matched study comparing patients with previous upper abdominal surgery to patients without such previous surgery, no differences were found.[120]

Proposed Action. Prospective database studies and registries should improve the quality of evidence on this recommendation.

Q14. Does MIPR Offer Advantages Over the Open Approach for Patients With Elevated Comorbidity?

Recommendation. The evidence to suggest a relationship between comorbidity and the outcome of MIPR is limited in quality and quantity (GRADE 2C, expert agreement 97.5%, quality score 55.0%, audience agreement 75.0%).

Comments. One study compared LDP with ODP and performed subgroup analyses in high-risk patients (ASA III–IV). The high-risk LDP group (n = 15) showed a shorter operative time, less blood loss, a higher rate of spleen preservation, fewer complications, and a shorter hospital stay compared with high-risk ODP (n = 32).[120]

Proposed Action. Centers with prospectively maintained databases should compare both approaches, stratify, and do subgroup analysis according to patient comorbidity. A comorbidity index specific for pancreatic surgery should be developed and validated.

Q15. What Are the Optimal Techniques for Control of Hemorrhage During MIPR?

Recommendation. No evidence exists which specifically addresses the relative benefits of any particular hemostatic technique in MIPR (GRADE 1C, upgraded from 2C, quality score 50.0%, audience agreement 89.0%).

Comments. No literature addressing this topic was identified.

Proposed Action. Experienced surgeons with low intraoperative bleeding rates should publish their techniques of prevention and control of bleeding. A collaborative expert opinion manuscript is encouraged.

Q16. When Should a Surgeon Consider Conversion to an Open Approach (Contributing Factors and Timing of Conversion)?

Recommendation. No evidence exists to clearly determine the appropriate timing or indication for conversion in MIPR. Elective conversion should be considered based on surgeon experience, concern for patient safety, or failure to progress. The surgeon is expected to have expertise in various methods to control bleeding in the event of hemorrhage that may require urgent conversion (GRADE 1C, upgraded from 2C, expert agreement 97.5%, quality score 38.0%, audience agreement 100.0%).

Comments. Risk factors associated with an increased conversion rate are smoking, elevated BMI, surgeon case experience, and malignancy.[121–126] No studies specifically assessed the timing of conversion.

Proposed Action. Authors are encouraged to record reasons for conversion, elective/preemptive versus urgent, and timing of conversion.

Training and Implementation

Q17. What Is the Value of Formal MIPR Training?

Recommendation. The value of formal MIPR training is the safe introduction and expansion of MIPR. Participation in a structured training program is strongly recommended for all surgeons undertaking MIPR. A structured MIPR training program may include virtual reality simulation, inanimate biotissue models to practice dissection and anastomotic techniques, surgical video review, on-site proctoring, and remote tele-mentorship (GRADE 1C, upgraded from 2C, expert agreement 97.5%, quality score 79.0%, audience agreement 95.0%).

Comments. Training programs for MIDP,[18] LPD,[19] and RPD[20] have been described. A steep increase in the use of MIDP was seen after training, and blood loss and conversion rate decreased.[18] Surgical outcomes of LPD during and after training were in line with those of OPD.[19] The training program for RPD describes a structured training that consists of the following steps: virtual reality simulation, biotissue curriculum, video library training, intraoperative evaluation, and skill maintenance with ongoing assessment.[20] The evaluation of the RPD training program showed that fellows increasingly performed a complete procedure.[127] The first 2 steps of the RPD training program are reported separately; step 1 is a virtual reality robotic simulation curriculum[128] and step 2 a biotissue drill on the robot simulating the steps of PD.[129] Both show improvement of outcomes after completing these steps.

Proposed Action. HPB training programs should specify whether MIS is part of their curriculum and if so, formalize its structure.

Q18. Does Surgeon Volume Affect Outcomes After MIPR?

Recommendation. The annual individual surgeon's volume affects individual surgeon's outcomes. Single surgeon learning curves for MIPR show improvements in operative time, blood loss, lymph node harvest, and complications with increased total volume/experience; however, the exact number remains to be defined (Grade 2C, expert agreement 95.0%, quality score 77.0%, audience agreement 96.0%).

Comments. Depending on the outcome that was used to assess the learning curve, 10 to 40 cases have been described to be required to reach proficiency in LDP.[66,130–136] For RDP, the number of cases described is 7 to 37.[131,137,138] In LPD learning curve, related improvements in outcome were seen after 10–50 cases.[66,139–142] For RPD, 20 to 40 cases have been described as needed to overcome the learning curve.[74,138,143,144] Data on annual surgeon volume are not available.

Proposed Action. More studies are needed to address the optimal metric to assess the minimum number of cases needed to accomplish competency and good outcomes. Multi-institutional studies and registries are likely the best sources of data. Outcomes and video assessment studies are encouraged.

Q19. Are There Recommended Prerequisites for Surgeons Embarking on MIPR? Should the Presence of a Second Surgeon Be Required During Early Learning Curve?

Recommendation. No specific studies assess prerequisites for MIPR. Experience in pancreatic surgery, including a formal fellowship training or an established practice as a pancreatic surgeon, is advised. A 2-surgeon approach can be beneficial in the learning curve, although comparative evidence is lacking (GRADE 1C, upgraded from 2C, expert agreement 97.5%, quality score 77.0%, audience agreement 98.0%).

Comments: No evidence exists on a 2-surgeon approach in MIPR. A study comparing outcomes of LDP performed by expert surgeons and surgeons in training reports comparable outcomes.[145]

Proposed Action: Centers performing MIPR are recommended to participate in prospective registries and include these data points.

Q20. Does Center Volume Affect Outcomes of MIPR?

Recommendation. Center volume strongly affects outcomes after MIPR and consideration of total pancreas resection volume along with MIPR specific volume is critical. MIPD should be performed in high volume centers since mortality (for centers performing <10 MIPD/year) and morbidity (for centers performing <20 MIPD/year) are worse when performed in a low volume setting (GRADE 1B, expert agreement 97.5%, quality score 82.0%, audience agreement 85.0%).

Comments. Center volume is associated with morbidity[105,146] and mortality[72,104,147] when PD[104,105,147] and MIPD volume are analyzed.[72,146] A decreased complication rate was seen in centers performing >20 MIPD/year[146] or >20 total PD/year.[105] Mortality rates decreased from an annual volume of >10 total PD or MIPD.[72,104,147]

Proposed Action. Centers performing MIPR are recommended to participate in prospective registries. As a result, more data regarding center volume and outcomes will become accessible.

Q21. What Are Essential Requirements for a MIPR Program?

Recommendation. No specific evidence exists on requirements for a MIPR program. However, centers undertaking MIPR should consider including the following components: implementation of dedicated individual and team training, having >1 surgeon performing MIPR at the institution, monitoring outcomes of MIPR for quality assurance, consideration of surgeon/institution volume of pancreas resections including MIPR (GRADE 2C, upgraded from EXPERT OPINION, expert agreement 97.5%, quality score 75.0%, audience agreement 93.0%).

Comments. No literature addressing this topic was identified.

Proposed Action. Centers and surgeons embarking in MIPR should use these guidelines as they develop a new MIPR program.

Instrumentation

Q22. Do Safety Advantages Exist for Specific Energy Devices?

Recommendation. No documented advantages for any specific energy device have been reported (GRADE expert opinion, downgraded from 2C, expert agreement 100.0%, quality score 51.0%, audience agreement 96.0%).

Comments. No literature addressing this topic was identified.

Proposed actions: Each surgeon should use the energy device they favor and are most familiarized with.

Q23. Does a Need Exist to Develop New Instrumentation for MIPR?

Recommendation. The development of instruments and enhanced visualization systems for MIPR should be encouraged (EXPERT OPINION, downgraded from 2C, expert agreement 97.5%, quality score 63.0%, audience agreement 89.0%).

Comments. Two studies regarding the use of augmented reality in pancreatic surgery concluded that this approach might increase surgical efficacy.[148,149]

Proposed Action. Cooperation between surgeons and industry should be encouraged for the production of specific instrumentation for MIPR.

Accountability

All recommendations regarding accountability are based on expert opinion, as a result of lacking evidence.

Q24. What is the Current Status and Value of Registries for MIPR?

Recommendation. There are currently several registries for MIPR in development. The inclusion of patient data into thoughtfully organized and maintained regional, national, and international registries supported by HPB organizations is strongly encouraged to follow trends and outcomes, and to assess quality (EXPERT OPINION, expert agreement 100.0%, quality score 82.0%, audience agreement 100.0%).

Comments. No literature addressing this topic was identified. Several registries have been established on the last 5 years and served as the source for multiple MIPR-related reports.

Proposed actions: Surgical societies and pancreatic surgery consortiums should consider raising awareness on the benefits of participating in a registry and award some type of recognition to the participant institutions.

Q25. For MIPD, Should It Be Mandatory to Follow Outcomes and Belong to a Registry?

Recommendation. Outcome monitoring of MIPD is essential for its safe and wide expansion. Inclusion into validated regional, national, and international registries is highly recommended (Expert Opinion, expert agreement 100.0%, quality score 82.0%, audience agreement 98.0%).

Comments. No literature addressing this topic was identified.

Proposed Action. It should be mandatory and considered standard of care to follow outcomes in a prospectively-maintained database for centers performing MIPD. This recommendation should also be applied to OPD.

Q26. What Should Be the Role of Surgical Societies in the Development and Implementation of MIPR?

Recommendation. The development and the expansion of MIPR should be encouraged and monitored by national and international societies through the promotion of specific working groups who will drive training and registries to ensure patient safety and quality improvement (Expert Opinion, expert agreement 97.5%, quality score 82.0%, audience agreement 100.0%).

Comments. No literature addressing this topic was identified.

Proposed Action: Creation and implementation of international and national MIPR working groups should occur within existing HPB societies and chapters.

DISCUSSION

MIPR has seen rapid development over the past decade and outcomes, particularly for MIPD, have varied significantly. Although experienced centers have reported excellent outcomes, suboptimal results have also been reported, and there are multiple anecdotal accounts of poor outcomes that are not recorded in the literature. This variance calls for attention to the lack of directives on how to appropriately train, safely implement, and expand MIPR.

One should not expect the current evidence-based guidelines would address and solve all issues related to MIPR. They should rather be seen as a progressive step in what hopefully would be a continuous international collaborative effort for the unbiassed assessment and appropriate dissemination of MIPR. These guidelines also underline areas in which further research and development are needed.

It appears that open, laparoscopic, and robotic pancreas resections are all here to stay. The first randomized trials are now available, which compare outcomes between these approaches. Apart from designing new randomized trials, future studies should also help us better understand the role that each approach plays.

More importantly, future studies should focus on how these technical advances can make the operation better and reduce known complications such as pancreatic fistula, delayed gastric emptying, and infections.

The IG-MIPR meeting was organized to review the available evidence, design evidence-based recommendations among a wide range of open, laparoscopic, and robotic international pancreas experts, and develop specific guideline statements through a rigorous methodology. The guidelines have been endorsed by 8 major surgical societies who participated in the planning and execution of the meeting. This process illustrates a true international collaborative effort with a group of experts from >20 countries.

During the first Delphi, only 3 recommendations did not reach 85% consensus among the 40 voting experts (4b, 14b, and 18). Per the established methodology, validation committee members, reviewers, and the chair of IG-MIPR (HA) did not participate in the voting. For the second Delphi, modifications were made based on the feedback received on the first Delphi and all three statements passed the 85.0% minimal approval rate. All statements approved on the Delphi process were presented in the meeting for audience voting and validation statement regarding the absence of contraindications to MIPR in high-risk patients had an 82.0% audience approval but was excluded by the Validation Committee as it was redundant. The expert and audience approvals, as well as quality scores provided by the Validation Committee, varied among PICO and Non-PICO questions (Supplementary Figure S1, http://links.lww.com/SLA/B781). Experts' approval for all the statements after the second Delphi was 97.5% (85.0–100.0, median and range), the audience agreement was 94.3% (51.1–100.0), and quality scores by the Validation Committee were 75.0% (29.0–90.0). Despite high expert and audience approval rates, and high-quality scores for left pancreatectomy [97.5% (85.0–100); 91.8% (82.0–100.0); 85.0% (82.0–90.0); respectively], quality scores for MIPD were low [95.0% (90.0–100.0); 91.6% (87.3–98.1); 41.0% (30.0–70.0)]. Non-PICO

questions followed the same trend of high expert and audience agreements, with a quality score of 70.0% [97.5% (87.5–100.0); 95.6% (51.1–100.0); 70.0% (29.0–82.0)].

The main purpose of the PICO questions (Q1–12) was to compare MIPR with OPR in aspects such as surgical outcomes, QoL, costs, and feasibility. When comparing MIDP with MIPD, MIDP has a greater number of studies, and the evidence level is higher, resulting in recommendations which are more clearly favoring MIPR. Nevertheless, despite good quality scores, there are still insufficient data on spleen preservation, best pancreatic stump closure methods, and central pancreatectomy, both for open and MIPR.

Three randomized studies have directly compared LPD and OPD, with contradicting results with respect to safety, and replicability. Two of these studies favoring LPD[16,17] are limited by small numbers and by being from a single-institution/surgeon highly experienced in MIS. The one study showing negative result for LPD,[15] appeared to be better designed, was multi-institutional and included a larger number of patients. However, the study was limited by the surgeons' experience on MIPD, as a surgeon was qualified to participate in the study after completing only 20 MIPDs. This seems to be reflected in the type of complications that led to the trend of increased mortality in the MIPD group, which resulted in early termination of the study.

During the process of developing the IG-MIPR guidelines, it became evident that in every perioperative phase of MIPR, both an opportunity and a need exist for further research. Preoperatively, there are gaps in the understanding which is the best comorbidity assessement to use for pancreatic surgery. An objective analysis of which parameters would better select patients and favor or contraindicate a particular approach, is needed.

Intraoperatively, there are very few studies addressing preemptive vascular control, timing, and reason for conversion. Good-quality, comparative studies on the best ways to address the pancreato-jejunostomy in MIPD and pancreas stump closure in MIDP are also lacking. Postoperatively, studies on QoL and analysis of costs are limited.

The need for data registries and formal training in MIPR was also repeatedly stressed during the meeting. Also, the definition of high- and low-volume centers and their role in MIPR needs to be improved. In the future, the combination of mandatory outcomes recording and formal MIPR training programs will likely lead to national hospital accreditation to MIPR. Based on the current evidence, it was recommended that centers should perform at least 20 MIPD per year to prevent increased morbidity as compared to OPD.

A main point of the meeting was emphasizing that MIPR has progressive levels of technical refinement that range from enucleations to highly complex surgeries with vascular resections. As such, it was agreed that centers should have a process for safe implementation of MIPR and participation in registries, which allow for future comparative studies. Evaluation of a particular procedure's benefit is better done in places that have already attained the learning curve for MIPR. Nevertheless, better studies are needed to assess what is, and how to address such a learning curve.

During the meeting, it was also stressed that similar standards should apply to open pancreas resections. Clear expert and audience agreement advocated that following outcomes and participation in registries should also be mandated for OPD.

With the recent rapid growth of MIPR, the Miami Guidelines provide up-to-date evidence as well as expert opinion. As technology advances, adoption increases, registries are expanded, and collaborative studies are produced, and there will be a need to revisit these guidelines in future years. Updates should be done using a strict methodology and fostering participation and partnership of a focused, but diverse group of international experts.

SUMMARY

The IG-MIPR effort illustrates a strong collaboration of multiple and diverse pancreas experts from around the world, bridging the domains of open, laparoscopic, and robotic surgery.

The Miami Guidelines are a starting point. As more and more studies are being done to increase the knowledge available in MIPR, better evidence will come to light on the differences in outcomes between open, laparoscopic, and robotic surgery, costs variance, QoL, the rationale for conversion, and best ways for training and implementation.

What is clear is that laparoscopic, robotic, and open pancreas resections each have a role. Future randomized trials and studies should focus on better understanding the specific utility and benefits of each approach and how technical advances can improve outcomes. The recommendations defined during the IG-MIPR Miami meeting should guide current pancreas surgeons and institutions on the role of MIPR in pancreatic surgery, foster its safe implementation, and guide future advances.

ACKNOWLEDGMENT

The authors acknowledge Isabel Rodriguez-Morgan for her invaluable support as well as Julie Zimmett and the Baptist Health Continuing Medical Education Department.

The authors also acknowledge Baptist Health Foundation and the following Surgical Societies for their financial support to the MIPR meeting:

- Tier 1 support: AHPBA, SAGES, SSAT.
- Tier 2 support: IHPBA, E-AHPBA, EAES, SSO.

REFERENCES

1. Røsok BI, Marangos IP, Kazaiyan AM, et al. Single-centre experience of laparoscopic pancreatic surgery. *Br J Surg*. 2010;97:902–909.
2. Song KB, Kim SC, Park JB, et al. Single-center experience of laparoscopic left pancreatic resection in 359 consecutive patients: changing the surgical paradigm of left pancreatic resection. *Surg Endosc*. 2011;25:3364–3372.
3. Butturini G, Partelli S, Crippa S, et al. Perioperative and long-term results after left pancreatectomy: A single-institution, non-randomized, comparative study between open and laparoscopic approach. *Surg Endosc*. 2011;25:2871–2878.
4. Jayaraman S, Gonen M, Brennan MF, et al. Laparoscopic distal pancreatectomy: evolution of a technique at a single institution. *J Am Coll Surg*. 2010;211:503–509.
5. Asbun HJ, Stauffer JA. Laparoscopic vs open pancreaticoduodenectomy: overall outcomes and severity of complications using the accordion severity grading system. *J Am Coll Surg*. 2012;215:810–819.
6. Chalikonda S, Aguilar-Saavedra JR, Walsh RM. Laparoscopic robotic-assisted pancreaticoduodenectomy: a case-matched comparison with open resection. *Surg Endosc*. 2012;26:2397–2402.
7. Abu Hilal M, Jain G, Kasasbeh F, et al. Laparoscopic distal pancreatectomy: critical analysis of preliminary experience from a tertiary referral centre. *Surg Endosc Other Interv Tech*. 2009;23:2743–2747.
8. Stauffer JA, Coppola A, Mody K, et al. Laparoscopic versus open distal pancreatectomy for pancreatic adenocarcinoma. *World J Surg*. 2016;40:1477–1484.
9. Kooby DA, Gillespie T, Bentrem D, et al. Left-sided pancreatectomy: a multicenter comparison of laparoscopic and open approaches. *Ann Surg*. 2008;248:438–446.
10. Kooby DA, Hawkins WG, Schmidt CM, et al. A multicenter analysis of distal pancreatectomy for adenocarcinoma: is laparoscopic resection appropriate? *J Am Coll Surg*. 2010;210:779–785.
11. Mabrut JY, Fernandez-Cruz L, Azagra JS, et al. Laparoscopic pancreatic resection: Results of a multicenter European study of 127 patients. *Surgery*. 2005;137:597–605.
12. Zureikat AH, Postlewait LM, Liu Y, et al. A multi-institutional comparison of perioperative outcomes of robotic and open pancreaticoduodenectomy. *Ann Surg*. 2016;264:640–649.

13. Nassour I, Wang SC, Christie A, et al. Minimally invasive versus open pancreaticoduodenectomy. *Ann Surg*. 2018;268:151–157.
14. de Rooij T, van Hilst J, van Santvoort H, et al. Minimally invasive versus open distal pancreatectomy (LEOPARD): a multicenter patient-blinded randomized controlled trial. *Ann Surg*. 2019;269:2–9.
15. van Hilst J, De Rooij T, Bosscha K, et al. Laparoscopic versus open pancreatoduodenectomy for pancreatic or periampullary tumours (LEOPARD-2): a multicentre, patient-blinded, randomised controlled phase 2/3 trial. *Lancet Gastroenterol Hepatol*. 2019;4:199–207.
16. Poves I, Burdío F, Morató O, et al. Comparison of perioperative outcomes between laparoscopic and open approach for pancreatoduodenectomy. *Ann Surg*. 2018;268:1.
17. Palanivelu C, Senthilnathan P, Sabnis SC, et al. Randomized clinical trial of laparoscopic versus open pancreatoduodenectomy for periampullary tumours. *Br J Surg*. 2017;104:1443–1450.
18. De Rooij T, Van Hilst J, Boerma D, et al. Impact of a nationwide training program in minimally invasive distal pancreatectomy (LAELAPS). *Ann Surg*. 2016;264:754–762.
19. de Rooij T, van Hilst J, Topal B, et al. Outcomes of a multicenter training program in laparoscopic pancreatoduodenectomy (LAELAPS-2). *Ann Surg*. 2019;269:344–350.
20. Knab LM, Zureikat AH, Zeh HJ, et al. Towards standardized robotic surgery in gastrointestinal oncology. *Langenbeck's Arch Surg*. 2017;402:1003–1014.
21. Vollmer CM, Asbun HJ, Barkun J, et al. Proceedings of the first international state-of-the-art conference on minimally-invasive pancreatic resection (MIPR). *Hpb*. 2017;19:171–177.
22. Bassi C, Andrianello S. Identifying key outcome metrics in pancreatic surgery, and how to optimally achieve them. *HPB*. 2017;19:178–181.
23. Montagnini AL, Røsok BI, Asbun HJ, et al. Standardizing terminology for minimally invasive pancreatic resection. *HPB*. 2017;19:182–189.
24. van Hilst J, de Rooij T, Abu Hilal M, et al. Worldwide survey on opinions and use of minimally invasive pancreatic resection. *Hpb*. 2017;19:190–204.
25. Røsok BI, de Rooij T, van Hilst J, et al. Minimally invasive distal pancreatectomy. *HPB*. 2017;19:205–214.
26. Kendrick ML, van Hilst J, Boggi U, et al. Minimally invasive pancreatoduodenectomy. *HPB*. 2017;19:215–224.
27. Conlon KC, de Rooij T, van Hilst J, et al. Minimally invasive pancreatic resections: cost and value perspectives. *HPB*. 2017;19:225–233.
28. Hogg ME, Besselink MG, Clavien PA, et al. Training in Minimally invasive pancreatic resections: a paradigm shift away from ''See one, Do one, Teach one.''. *HPB*. 2017;19:234–245.
29. Barkun J, Fisher W, Davidson G, et al. Research considerations in the evaluation of minimally invasive pancreatic resection (MIPR). *HPB*. 2017;19:246–253.
30. SIGN 50: a guideline developer's handbook. Available at: https://www.sign.ac.uk/sign-50.html. Accessed May 1, 2019.
31. Grading Tutorial. Available at: https://www.uptodate.com/home/grading-tutorial. Accessed May 1, 2019.
32. AGREE II: advancing guideline development, reporting and evaluation in health care. *Can Med Assoc J*. 2010;182:E839–E842.
33. Jin T, Altaf K, Xiong JJ, et al. A systematic review and meta-analysis of studies comparing laparoscopic and open distal pancreatectomy. *HPB*. 2012;14:711–724.
34. Venkat R, Edil BH, Schulick RD, et al. Laparoscopic distal pancreatectomy is associated with significantly less overall morbidity compared to the open technique: a systematic review and meta-analysis. *Ann Surg*. 2012;255:1048–1059.
35. Jusoh AC, Ammori BJ. Laparoscopic versus open distal pancreatectomy: a systematic review of comparative studies. *Surg Endosc*. 2012;26:904–913.
36. Mehrabi A, Hafezi M, Arvin J, et al. A systematic review and meta-analysis of laparoscopic versus open distal pancreatectomy for benign and malignant lesions of the pancreas: it's time to randomize. *Surg (United States)*. 2015;157:45–55.
37. Nakamura M, Nakashima H. Laparoscopic distal pancreatectomy and pancreatoduodenectomy: is it worthwhile? A meta-analysis of laparoscopic pancreatectomy. *J Hepatobiliary Pancreat Sci*. 2013;20:421–428.
38. Nigri GR, Rosman AS, Petrucciani N, et al. Metaanalysis of trials comparing minimally invasive and open distal pancreatectomies. *Surg Endosc*. 2011;25:1642–1651.
39. Qiu J, Chen S, Prasoon P, et al. Meta-analysis of laparoscopic versus open distal pancreatectomy for pancreatic diseases. *Surg Pract*. 2013;17:49–57.
40. Pericleous S, Middleton N, McKay SC, et al. Systematic review and meta-analysis of case-matched studies comparing open and laparoscopic distal pancreatectomy: is it a safe procedure? *Pancreas*. 2012;41:993–1000.
41. Sui CJ, Li B, Yang JM, et al. Laparoscopic versus open distal pancreatectomy: a meta-analysis. *Asian J Surg*. 2012;35:1–8.
42. Xie K, Zhu YP, Xu XW, et al. Laparoscopic distal pancreatectomy is as safe and feasible as open procedure: a meta-analysis. *World J Gastroenterol*. 2012;18:1959–1967.
43. Joechle K, Conrad C. Cost-effectiveness of minimally invasive pancreatic resection. *J Hepatobiliary Pancreat Sci*. 2018;25:291–298.
44. Gurusamy KS, Riviere D, Laarhoven CJH Van. et al. Cost-effectiveness of laparoscopic versus open distal pancreatectomy for pancreatic cancer. *PLoS One*. 2017;12:e0189631.
45. Braga M, Pecorelli N, Ferrari D, et al. Results of 100 consecutive laparoscopic distal pancreatectomies: postoperative outcome, cost-benefit analysis, and quality of life assessment. *Surg Endosc*. 2015;29:1871–1878.
46. Riviere D, Gurusamy SK, Kooby DA, et al. Laparoscopic versus open distal pancreatectomy for pancreatic cancer. *Cochrane database Syst Rev*. 2016;1–64.
47. van Hilst J, Korrel M, de Rooij T, et al. Oncologic outcomes of minimally invasive versus open distal pancreatectomy for pancreatic ductal adenocarcinoma: a systematic review and meta-analysis. *Eur J Surg Oncol*. 2019;45:719–727.
48. Xia T, Zhou JY, Mou YP, et al. Risk factors for postoperative pancreatic fistula after laparoscopic distal pancreatectomy using stapler closure technique from one single surgeon. *PLoS One*. 2017;12:e0172857.
49. Nakamura M, Ueda J, Kohno H, et al. Prolonged peri-firing compression with a linear stapler prevents pancreatic fistula in laparoscopic distal pancreatectomy. *Surg Endosc*. 2011;25:867–871.
50. Ceppa EP, McCurdy RM, Becerra DC, et al. Does pancreatic stump closure method influence distal pancreatectomy outcomes? *J Gastrointest Surg*. 2015;19:1449–1456.
51. Kim H, Jang JY, Son D, et al. Optimal stapler cartridge selection according to the thickness of the pancreas in distal pancreatectomy. *Med (United States)*. 2016;95:e4441.
52. Asbun HJ, Van Hilst J, Tsamalaidze L, et al. Technique and audited outcomes of laparoscopic distal pancreatectomy combining the clockwise approach, progressive stepwise compression technique, and staple line reinforcement. *Surg Endosc*. Epub ahead of print May 2019. DOI: 10.1007/s00464-019-06757-3.
53. Montorsi M, Zerbi A, Bassi C, et al. Efficacy of an absorbable fibrin sealant patch (TachoSil) after distal pancreatectomy. *Ann Surg*. 2012;256:853–860.
54. Sa Cunha A, Carrere N, Meunier B, et al. Stump closure reinforcement with absorbable fibrin collagen sealant sponge (TachoSil) does not prevent pancreatic fistula after distal pancreatectomy: The FIABLE multicenter controlled randomized study. *Am J Surg*. 2015;210:739–748.
55. Marangos IP, Røsok BI, Kazaryan AM, et al. Effect of TachoSil patch in prevention of postoperative pancreatic fistula. *J Gastrointest Surg*. 2011;15:1625–1629.
56. Hamilton NA, Porembka MR, Johnston FM, et al. Mesh reinforcement of pancreatic transection decreases incidence of pancreatic occlusion failure for left pancreatectomy. *Ann Surg*. 2012;255:1037–1042.
57. Niu X, Yu B, Yao L, et al. Comparison of surgical outcomes of robot-assisted laparoscopic distal pancreatectomy versus laparoscopic and open resections: a systematic review and meta-analysis. *Asian J Surg*. 2019;42:32–45.
58. Zhou JY, Xin C, Mou YP, et al. Robotic versus laparoscopic distal pancreatectomy: a meta-analysis of short-term outcomes. *PLoS One*. 2016;11:e0151189.
59. Gavriilidis P, Lim C, Menahem B, et al. Robotic versus laparoscopic distal pancreatectomy—the first meta-analysis. *HPB*. 2016;18:567–574.
60. Xu SB, Jia CK, Wang JR, et al. Do patients benefit more from robot assisted approach than conventional laparoscopic distal pancreatectomy? A meta-analysis of perioperative and economic outcomes. *J Formos Med Assoc*. 2019;118:268–278.
61. Huang B, Feng L, Zhao J. Systematic review and meta-analysis of robotic versus laparoscopic distal pancreatectomy for benign and malignant pancreatic lesions. *Surg Endosc*. 2016;30:4078–4085.
62. Liu R, Liu Q, Zhao ZM, et al. Robotic versus laparoscopic distal pancreatectomy: a propensity score-matched study. *J Surg Oncol*. 2017;116:461–469.
63. Raoof M, Nota CLMA, Melstrom LG, et al. Oncologic outcomes after robot-assisted versus laparoscopic distal pancreatectomy: analysis of the National Cancer Database. *J Surg Oncol*. 2018;118:651–656.

64. Lyman WB, Passeri SC, Sastry KM, et al. Robotic-assisted versus laparoscopic left pancreatectomy at a high-volume, minimally invasive center. *Surg Endosc*. 2019;33:2991–3000.
65. Song KB, Kim SC, Park KM, et al. Laparoscopic central pancreatectomy for benign or low-grade malignant lesions in the pancreatic neck and proximal body. *Surg Endosc*. 2015;29:937–946.
66. Dokmak S, Ftériche FS, Aussilhou B, et al. The largest European single-center experience: 300 laparoscopic pancreatic resections. *J Am Coll Surg*. 2017;225:226–234. e2.
67. Guerra F, Giuliani G, Bencini L, et al. Minimally invasive versus open pancreatic enucleation. Systematic review and meta-analysis of surgical outcomes. *J Surg Oncol*. 2018;117:1509–1516.
68. Zhou Y, Zhao M, Wu L, et al. Short- and long-term outcomes after enucleation of pancreatic tumors: an evidence-based assessment. *Pancreatology*. 2016;16:1092–1098.
69. Song KB, Kim SC, Hwang DW, et al. Enucleation for benign or low-grade malignant lesions of the pancreas: single-center experience with 65 consecutive patients. *Surg (United States)*. 2015;158:1203–1210.
70. Shi Y, Peng C, Shen B, et al. Pancreatic enucleation using the da Vinci robotic surgical system: a report of 26 cases. *Int J Med Robot Comput Assist Surg*. 2016;12:751–757.
71. Tian F, Hong XF, Wu WM, et al. Propensity score-matched analysis of robotic versus open surgical enucleation for small pancreatic neuroendocrine tumours. *Br J Surg*. 2016;103:1358–1364.
72. Sharpe SM, Talamonti MS, Wang CE, et al. Early national experience with laparoscopic pancreaticoduodenectomy for ductal adenocarcinoma: A comparison of laparoscopic pancreaticoduodenectomy and open pancreaticoduodenectomy from the National Cancer Data Base. *J Am Coll Surg*. 2015;221:175–184.
73. Bao PQ, Mazirka PO, Watkins KT. Retrospective comparison of robot-assisted minimally invasive versus open pancreaticoduodenectomy for periampullary neoplasms. *J Gastrointest Surg*. 2014;18:682–689.
74. Chen S, Chen JZ, Zhan Q, et al. Robot-assisted laparoscopic versus open pancreaticoduodenectomy: a prospective, matched, mid-term follow-up study. *Surg Endosc*. 2015;29:3698–3711.
75. Chen XM, Sun DL, Zhang Y. Laparoscopic versus open pancreaticoduodenectomy combined with uncinated process approach: a comparative study evaluating perioperative outcomes (Retrospective cohort study). *Int J Surg*. 2018;51:170–173.
76. Chopinet S, Fuks D, Rinaudo M, et al. Postoperative bleeding after laparoscopic pancreaticoduodenectomy: the Achilles' heel? *World J Surg*. 2018;42:1138–1146.
77. Conrad C, Basso V, Passot G, et al. Comparable long-term oncologic outcomes of laparoscopic versus open pancreaticoduodenectomy for adenocarcinoma: a propensity score weighting analysis. *Surg Endosc*. 2017;31:3970–3978.
78. Croome KP, Farnell MB, Que FG, et al. Total laparoscopic pancreaticoduodenectomy for pancreatic ductal adenocarcinoma oncologic advantages over open approaches? *Ann Surg*. 2014;260:633–640.
79. Croome KP, Farnell MB, Que FG, et al. Pancreaticoduodenectomy with major vascular resection: a comparison of laparoscopic versus open approaches. *J Gastrointest Surg*. 2014;19:189–194.
80. Delitto D, Luckhurst CM, Black BS, et al. Oncologic and perioperative outcomes following selective application of laparoscopic pancreaticoduodenectomy for periampullary malignancies. *J Gastrointest Surg*. 2016;20:1343–1349.
81. Dokmak S, Ftériche FS, Aussilhou B, et al. Laparoscopic pancreaticoduodenectomy should not be routine for resection of periampullary tumors. *J Am Coll Surg*. 2015;220:831–838.
82. Gerber MH, Delitto D, Crippen CJ, et al. Analysis of the cost effectiveness of laparoscopic pancreatoduodenectomy. *J Gastrointest Surg*. 2017;21:1404–1410.
83. Girgis MD, Zenati MS, Steve J, et al. Robotic approach mitigates perioperative morbidity in obese patients following pancreaticoduodenectomy. *Hpb*. 2017;19:93–98.
84. Kantor O, Talamonti MS, Sharpe S, et al. Laparoscopic pancreaticoduodenectomy for adenocarcinoma provides short-term oncologic outcomes and long-term overall survival rates similar to those for open pancreaticoduodenectomy. *Am J Surg*. 2017;213:512–515.
85. Kantor O, Pitt HA, Talamonti MS, et al. Minimally invasive pancreatoduodenectomy: is the incidence of clinically relevant postoperative pancreatic fistula comparable to that after open pancreatoduodenectomy? *Surg (United States)*. 2018;163:587–593.
86. Kim HS, Han Y, Kang JS, et al. Comparison of surgical outcomes between open and robot-assisted minimally invasive pancreaticoduodenectomy. *J Hepatobiliary Pancreat Sci*. 2018;25:142–149.
87. Klompmaker S, van Hilst J, Wellner UF, et al. Outcomes after minimally-invasive versus open pancreatoduodenectomy: a Pan-European Propensity Score Matched Study. *Ann Surg*. 2018.
88. Kowalsky SJ, Zenati MS, Steve J, et al. A combination of robotic approach and ERAS pathway optimizes outcomes and cost for pancreatoduodenectomy. *Ann Surg*. 2019;269:1138–1145.
89. Kuesters S, Chikhladze S, Makowiec F, et al. Oncological outcome of laparoscopically assisted pancreatoduodenectomy for ductal adenocarcinoma in a retrospective cohort study. *Int J Surg*. 2018;55:162–166.
90. Lai ECH, Yang GPC, Tang CN. Robot-assisted laparoscopic pancreaticoduodenectomy versus open pancreaticoduodenectomy—a comparative study. *Int J Surg*. 2012;10:475–479.
91. McCracken EKE, Mureebe L, Blazer DG. Minimally invasive surgical site infection in procedure-targeted ACS NSQIP pancreaticoduodenectomies. *J Surg Res*. 2019;233:183–191.
92. McMillan MT, Zureikat AH, Hogg ME, et al. A propensity score-matched analysis of robotic vs open pancreatoduodenectomy on incidence of pancreatic fistula. *JAMA Surg*. 2017;152:327–335.
93. Meng LW, Cai YQ, Li Y Bin, et al. Comparison of laparoscopic and open pancreaticoduodenectomy for the treatment of nonpancreatic periampullary adenocarcinomas. *Surg Laparosc Endosc Percutan Tech*. 2018;28:56–61.
94. Mesleh MG, Stauffer JA, Bowers SP, et al. Cost analysis of open and laparoscopic pancreaticoduodenectomy: a single institution comparison. *Surg Endosc*. 2013;27:4518–4523.
95. Napoli N, Kauffmann EF, Menonna F, et al. Robotic versus open pancreatoduodenectomy: a propensity score-matched analysis based on factors predictive of postoperative pancreatic fistula. *Surg Endosc*. 2018;32:1234–1247.
96. Nussbaum DP, Adam MA, Youngwirth LM, et al. Minimally invasive pancreaticoduodenectomy does not improve use or time to initiation of adjuvant chemotherapy for patients with pancreatic adenocarcinoma. *Ann Surg Oncol*. 2016;23:1026–1033.
97. Park YS, Jun IG, Go Y, et al. Comparison of acute kidney injury between open and laparoscopic pylorus-preserving pancreaticoduodenectomy: propensity score analysis. *PLoS One*. 2018;13:e0202980.
98. Senthilnathan P, Chinnusamy P, Ramanujam A, et al. Comparison of pathological radicality between open and laparoscopic pancreaticoduodenectomy in a tertiary centre. *Indian J Surg Oncol*. 2015;6:20–25.
99. Song KB, Kim SC, Hwang DW, et al. Matched case-control analysis comparing laparoscopic and open pylorus-preserving pancreaticoduodenectomy in patients with periampullary tumors. *Ann Surg*. 2015;262:146–155.
100. Stauffer JA, Coppola A, Villacreses D, et al. Laparoscopic versus open pancreaticoduodenectomy for pancreatic adenocarcinoma: long-term results at a single institution. *Surg Endosc*. 2017;31:2233–2241.
101. Baker EH, Ross SW, Seshadri R, et al. Robotic pancreaticoduodenectomy: comparison of complications and cost to the open approach. *Int J Med Robot Comput Assist Surg*. 2016;12:554–560.
102. Tan CL, Zhang H, Peng B, et al. Outcome and costs of laparoscopic pancreaticoduodenectomy during the initial learning curve vs laparotomy. *World J Gastroenterol*. 2015;21:5311–5319.
103. Tee MC, Croome KP, Shubert CR, et al. Laparoscopic pancreatoduodenectomy does not completely mitigate increased perioperative risks in elderly patients. *HPB*. 2015;17:909–918.
104. Torphy RJ, Friedman C, Halpern A, et al. Comparing short-term and oncologic outcomes of minimally invasive versus open pancreaticoduodenectomy across low and high volume centers. *Ann Surg*. 2018. C:1.
105. Tran TB, Dua MM, Worhunsky DJ, et al. The first decade of laparoscopic pancreaticoduodenectomy in the united states: costs and outcomes using the nationwide inpatient sample. *Surg Endosc*. 2016;30:1778–1783.
106. Wang SE, Shyr BU, Chen SC, et al. Comparison between robotic and open pancreaticoduodenectomy with modified Blumgart pancreaticojejunostomy: A propensity score-matched study. *Surg (United States)*. 2018;164:1162–1167.
107. Wellner UF, Küsters S, Sick O, et al. Hybrid laparoscopic versus open pylorus-preserving pancreatoduodenectomy: retrospective matched case comparison in 80 patients. *Langenbeck's Arch Surg*. 2014;399:849–856.
108. Zhang H, Guo X, Xia J, et al. Comparison of totally 3-dimensional laparoscopic pancreaticoduodenectomy and open pancreaticoduodenectomy. *Pancreas*. 2018;47:592–600.

109. Buchs NC, Addeo P, Bianco FM, et al. Robotic versus open pancreaticoduodenectomy: a comparative study at a single institution. *World J Surg*. 2011;35:2739–2746.
110. Chapman BC, Gajdos C, Hosokawa P, et al. Comparison of laparoscopic to open pancreaticoduodenectomy in elderly patients with pancreatic adenocarcinoma. *Surg Endosc*. 2018;32:2239–2248.
111. Chapman BC, Gleisner A, Ibrahim-Zada I, et al. Laparoscopic pancreaticoduodenectomy: changing the management of ampullary neoplasms. *Surg Endosc*. 2018;32:915–922.
112. Xourafas D, Pawlik TM, Cloyd JM. Independent predictors of increased operative time and hospital length of stay are consistent across different surgical approaches to pancreatoduodenectomy. *J Gastrointest Surg*. 2018;22:1911–1919.
113. Nassour I, Wang SC, Porembka MR, et al. Robotic versus laparoscopic pancreaticoduodenectomy: a NSQIP analysis. *J Gastrointest Surg*. 2017;21:1784–1792.
114. Nassour I, Choti MA, Porembka MR, et al. Robotic-assisted versus laparoscopic pancreaticoduodenectomy: oncological outcomes. *Surg Endosc*. 2018;32:2907–2913.
115. Orti-Rodríguez RJ, Rahman SH. A comparative review between laparoscopic and robotic pancreaticoduodenectomies. *Surg Laparosc Endosc Percutan Tech*. 2014;24:103–108.
116. Sahakyan MA, Edwin B, Kazaryan AM, et al. Perioperative outcomes and survival in elderly patients undergoing laparoscopic distal pancreatectomy. *J Hepatobiliary Pancreat Sci*. 2017;24:42–48.
117. Souche R, Fuks D, Perinel J, et al. Impact of laparoscopy in patients aged over 70 years requiring distal pancreatectomy: a French multicentric comparative study. *Surg Endosc*. 2018;32:3164–3173.
118. Chen K, Pan Y, Mou YP, et al. Surgical outcomes of laparoscopic distal pancreatectomy in elderly and octogenarian patients: a single-center, comparative study. *Surg Endosc*. 2019;33:2142–2151.
119. Sahakyan MA, Røsok BI, Kazaryan AM, et al. Impact of obesity on surgical outcomes of laparoscopic distal pancreatectomy: a Norwegian single-center study. *Surgery*. 2016;160:1271–1278.
120. Liao C-H, Yeh C-N, Yang S-J, et al. Effectiveness and feasibility of laparoscopic distal pancreatectomy on patients at high anesthetic risk. *J Laparoendosc Adv Surg Tech*. 2014;24:865–871.
121. Casadei R, Ricci C, Pacilio CA, et al. Laparoscopic distal pancreatectomy: which factors are related to open conversion? Lessons learned from 68 consecutive procedures in a high-volume pancreatic center. *Surg Endosc*. 2018;32:3839–3845.
122. Hua Y, Javed AA, Burkhart RA, et al. Preoperative risk factors for conversion and learning curve of minimally invasive distal pancreatectomy. *Surg (United States)*. 2017;162:1040–1047.
123. Stiles ZE, Dickson PV, Deneve JL, et al. The impact of unplanned conversion to an open procedure during minimally invasive pancreatectomy. *J Surg Res*. 2018;227:168–177.
124. Goh BKP, Chan CY, Lee SY, et al. Factors associated with and consequences of open conversion after laparoscopic distal pancreatectomy: initial experience at a single institution. *ANZ J Surg*. 2017;87:E271–E275.
125. Zureikat AH, Borrebach J, Pitt HA, et al. Minimally invasive hepatopancreatobiliary surgery in North America: an ACS-NSQIP analysis of predictors of conversion for laparoscopic and robotic pancreatectomy and hepatectomy. *HPB*. 2017;19:595–602.
126. Nassour I, Wang SC, Porembka MR, et al. Conversion of minimally invasive distal pancreatectomy: predictors and outcomes. *Ann Surg Oncol*. 2017;24:3725–3731.
127. Mark Knab L, Zenati MS, Khodakov A, et al. Evolution of a novel robotic training curriculum in a complex general surgical oncology fellowship. *Ann Surg Oncol*. 2018;25:3445–3452.
128. Hogg ME, Tam V, Zenati M, et al. Mastery-based virtual reality robotic simulation curriculum: the first step toward operative robotic proficiency. *J Surg Educ*. 2017;74:477–485.
129. Tam V, Zenati M, Novak S, et al. Robotic pancreatoduodenectomy biotissue curriculum has validity and improves technical performance for surgical oncology fellows. *J Surg Educ*. 2017;74:1057–1065.
130. Barrie J, Ammori BJ. Minimally invasive distal pancreatectomy: a single-center analysis of outcome with experience and systematic review of the literature. *Surg Laparosc Endosc Percutaneous Tech*. 2015;25:297–302.
131. Benizri EI, Germain A, Ayav A, et al. Short-term perioperative outcomes after robot-assisted and laparoscopic distal pancreatectomy. *J Robot Surg*. 2014;8:125–132.
132. Braga M, Ridolfi C, Balzano G, et al. Learning curve for laparoscopic distal pancreatectomy in a high-volume hospital. *Updates Surg*. 2012;64:179–183.
133. de Rooij T, Cipriani F, Rawashdeh M, et al. Single-surgeon learning curve in 111 laparoscopic distal pancreatectomies: does operative time tell the whole story? *J Am Coll Surg*. 2017;224:826–832. e1.
134. Kneuertz PJ, Patel SH, Chu CK, et al. Laparoscopic distal pancreatectomy: trends and lessons learned through an 11-year experience. *J Am Coll Surg*. 2012;215:167–176.
135. Malleo G, Damoli I, Marchegiani G, et al. Laparoscopic distal pancreatectomy: analysis of trends in surgical techniques, patient selection, and outcomes. *Surg Endosc*. 2015;29:1952–1962.
136. Ricci C, Casadei R, Buscemi S, et al. Laparoscopic distal pancreatectomy: what factors are related to the learning curve? *Surg Today*. 2015;45:50–56.
137. Napoli N, Kauffmann EF, Perrone VG, et al. The learning curve in robotic distal pancreatectomy. *Updates Surg*. 2015;67:257–264.
138. Shyr BU, Chen SC, Shyr YM, et al. Learning curves for robotic pancreatic surgery-from distal pancreatectomy to pancreaticoduodenectomy. *Medicine (Baltimore)*. 2018;97:e13000.
139. Kim SC, Song KB, Jung YS, et al. Short-term clinical outcomes for 100 consecutive cases of laparoscopic pylorus-preserving pancreatoduodenectomy: Improvement with surgical experience. *Surg Endosc*. 2013;27:95–103.
140. Nagakawa Y, Nakamura Y, Honda G, et al. Learning curve and surgical factors influencing the surgical outcomes during the initial experience with laparoscopic pancreaticoduodenectomy. *J Hepatobiliary Pancreat Sci*. 2018;25:498–507.
141. Speicher PJ, Nussbaum DP, White RR, et al. Defining the learning curve for team-based laparoscopic pancreaticoduodenectomy. *Ann Surg Oncol*. 2014;21:4014–4019.
142. Wang M, Meng L, Cai Y, et al. Learning curve for laparoscopic pancreaticoduodenectomy: a CUSUM analysis. *J Gastrointest Surg*. 2016;20:924–935.
143. Takahashi C, Shridhar R, Huston J, et al. Outcomes associated with robotic approach to pancreatic resections. *J Gastrointest Oncol*. 2018;9:936–941.
144. Boone BA, Zenati M, Hogg ME, et al. Assessment of quality outcomes for robotic pancreaticoduodenectomy: identification of the learning curve. *JAMA Surg*. 2015;150:416–422.
145. Nakamura Y, Matsushita A, Katsuno A, et al. Laparoscopic distal pancreatectomy: educating surgeons about advanced laparoscopic surgery. *Asian J Endosc Surg*. 2014;7:295–300.
146. Adam MA, Thomas S, Youngwirth L, et al. Defining a hospital volume threshold for minimally invasive pancreaticoduodenectomy in the United States. *JAMA Surg*. 2017;152:336–342.
147. Kutlu OC, Lee JE, Katz MH, et al. Open pancreaticoduodenectomy case volume predicts outcome of laparoscopic approach: a population-based analysis. *Ann Surg*. 2018;267:552–560.
148. Yasuda J, Okamoto T, Onda S, et al. Novel navigation system by augmented reality technology using a tablet PC for hepatobiliary and pancreatic surgery. *Int J Med Robot Comput Assist Surg*. 2018;14:e1921.
149. Sugimoto M, Yasuda H, Koda K, et al. Image overlay navigation by markerless surface registration in gastrointestinal, hepatobiliary and pancreatic surgery. *J Hepatobiliary Pancreat Sci*. 2010;17:629–636.