Surgical Endoscopy (2019) 33:633–638
https://doi.org/10.1007/s00464-018-6488-2

DYNAMIC MANUSCRIPT

Laparoscopic duodenum-preserving total pancreatic head resection: a novel surgical approach for benign or low-grade malignant tumors

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Received: 22 July 2018 / Accepted: 11 October 2018 / Published online: 19 November 2018

Abstract

Background Duodenum-preserving total pancreatic head resection (DPPHRt) is an accepted alternative surgical procedure for benign or low-grade malignant tumors of the pancreatic head by preserving the duodenum with its intact blood supply from the pancreatic duodenal arterial arcade. This study describes our experience in laparoscopic DPPHRt (LDPPHRt). To our knowledge, this is the first description of this novel minimally invasive operation.

Methods From August 2016 to May 2017, all consecutive patients who underwent LDPPHRt for pancreatic head lesions at the HPB Surgery Department, Sun Yat-Sen Memorial Hospital in Guangzhou, China were enrolled into this retrospective study.

Results There were ten women and two men. The average age was 37.3 years (range 8–61 years). The average diameter of the pancreatic head lesions on pre-operative CT/MR was 3.7 cm (range 2–4.8 cm). All the LDPPHRt procedures were performed successfully. There was no peri-operative death. The average operative time was 272.5 min (range 210–320 min). The average blood loss was 215 ml (range 50–450 ml). Post-operative complications included pancreatic fistula grade B (two patients, or 16.7%) and biliary fistula (two patients, or 16.7%). All the complications responded well to conservative treatment. The mean post-operative hospital stay was 11.5 days (range 6–25 days).

Conclusions LDPPHRt provided a minimally invasive approach with good organ-preservation for benign or low-grade malignant tumors of the pancreatic head. The long-term oncological outcomes, and the exocrine and endocrine pancreatic functions after this operation require further studies.

Keywords Laparoscopic · Duodenum-preserving · Total pancreatic head resection · Benign or low-grade malignant tumors

Duodenum-preserving pancreatic head resection (DPPHR) was first described in the 1970s by Beger in Germany to treat patients with chronic pancreatitis [1, 2]. In 1988, Takada performed the first duodenum-preserving total pancreatic head resection (DPPHRt) to treat benign or low-grade malignant tumors of the pancreatic head by preserving the duodenum with its intact blood supply from the pancreatic duodenal arterial arcade [3, 4]. When compared with pancreaticoduodenectomy (PD), the standard operation for pancreatic head tumors, DPPHRt maintained the integrity of the duodenum and biliary system, with non-inferiority in the short- and long-term outcomes for benign or low-grade malignant tumors [5–7]. The rapid advancements in minimally invasive technology in the past two decades have led to the increasing use of laparoscopic pancreatic surgery. Laparoscopic PD and distal pancreatectomy (DP) are now technically feasible [8], although the long-term oncological outcomes remain unclear [9, 10]. Peng [11] in 2012 and Mouet [12] in 2016 reported the minimally invasive DPPHR. To our knowledge, there has been no report on laparoscopic DPPHRt probably because of the complex anatomy of the

This surgical approach had been presented as video presentation at the 13th IHPBA World Congress taking place in Geneva, Switzerland, 4–7 September 2018.

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pancreatic duodenal arterial arcade. In this article, a cohort of patients who underwent LDPPHRt as a novel minimally invasive surgery for benign or low-grade malignant tumors of the pancreatic head was reported.

Materials and methods

Patients

From August 2016 to May 2017, consecutive patients who underwent LDPPHRt were enrolled into this retrospective study.

Surgical procedures of LDPPHRt

The patient was placed in a reversed Trendelenburg position with head up 30° and leg splitting. The trocars were inserted according to the 5-port-method. Pneumoperitoneum was established with carbon dioxide at 14 mmHg. The gastrocolic ligament was opened to explore the head and neck of the pancreas and to check the location of the tumor without making a Kocher's maneuvre. The common hepatic artery (CHA) was looked for after removal of the group 8a lymph nodes. The CHA was dissected along its right side, separating and protecting the proper hepatic artery (PHA) and the gastro duodenal artery (GDA) after slinging these vessels with vascular slings. The uncinate process and pancreatic neck were dissected to expose the portal vein and the superior mesenteric vein (SMV).The portal vein-pancreas tunnel was built and the pancreatic neck and SMV were slinged with vascular slings. The capsule of the pancreas was cut open at the lower part of the pancreatic neck, and subcapsular dissection was carried out to the right, paying particular attention to visualize the pancreatic duodenal arterial arcade which passes along the duodenum. The lower part of the pancreatic head and uncinate process were separated to expose the inferior pancreatic duodenal arterial arcade which includes the anterior (AIPDA) and the posterior inferior pancreatic duodenal arteries (PIPDA). Care was taken to protect the branches which go into the duodenum. The pancreatic neck was transected with a Harmonic scissors in-front of the SMV. The pancreas head was separated from the right and dorsal edges of the SMV. The upper part of the pancreatic head was separated to expose the distal common bile duct (CBD) which lies inside the pancreas. The pancreas was dissected from the left and the dorsal edges of the CBD to expose and protect the posterior superior pancreatic duodenal artery (PSPDA), which comes from the GDA, with its branches going into the distal CBD and the ampulla of Vater. The anterior superior pancreatic duodenal artery (ASPDA) has to be cut usually for further deep dissection. Finally, the main pancreatic duct to the ampulla of Vater was dissected, ligated and cut off. The pancreatic head and uncinate process was totally resected and the specimen was removed. The blood supply to the CBD and duodenum was confirmed to be good (Fig. 1). The main pancreatic duct of the pancreatic body was found and an external ventricular drainage catheter was inserted. An end-to-side pancreaticojejunostomy (duct-to-mucosa) or pancreaticogastrostomy was done. The resected specimen was placed inside a bag and removed through a small lower abdominal incision. Two drainage catheters were positioned near the pancreaticojejunostomy and the CBD and brought out through two trocar port sites.

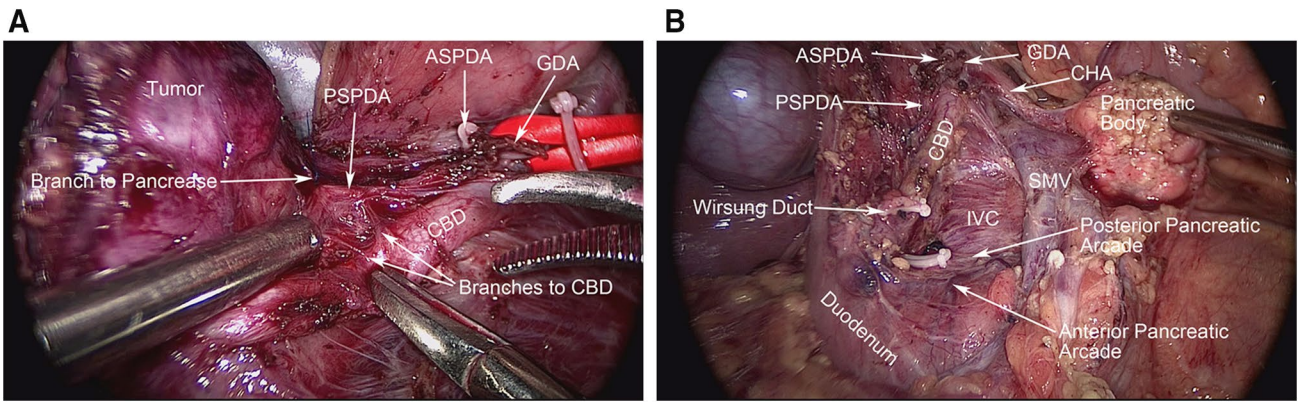

Fig. 1 Photos of laparoscopic duodenum-preserving total pancreatic head resection. **A** Dissect the pancreas from the left and dorsal edges of common bile duct (CBD), expose and protect posterior superior pancreatic duodenal artery (PSPDA), which comes from the gastro duodenal artery (GDA), with its branches going into the distal CBD and ampulla of Vater. Anterior superior pancreatic duodenal artery (ASPDA) has to be cut usually for further deep dissection. **B** Completion of total pancreatic head resection while preserving the duodenum, biliary tract and pancreatic duodenal arterial arcades

Results

During the study period, LDPPHRt was carried in 12 patients. There were ten women and two men. The average age was 37.3 years (range 8–61 years). Pre-operative CT/MR showed a pancreatic head lesion in all the patients. The average diameter of the pancreatic head lesions was 3.7 cm (range 2–4.8 cm). Most lesions were cystic neoplasms (9/12). In three patients, including a 8-year-old girl, the lesions were a solid-cystic neoplasm (Table 1). Tumor markers, including carcinoembryonic antigen (CEA), carbohydrate antigen (CA) 19-9, CA72-4, and CA12-5 were all normal.

All the LDPPHRt procedures were carried out successfully without any peri-operative deaths. The average operative time was 272.5 min (range 210–320 min). The average blood loss was 215 ml (range 50–450 ml). Most patients (11/12) underwent pancreaticojejunostomy (duct-to-mucosa). The remaining 8-year-old girl underwent pancreaticogastrostomy because of the proximity of the body of the pancreas to the stomach. Post-operative complications included pancreatic fistula grade B ($n=2$, 16.7%) and biliary fistula ($n=2$, 16.7%), including a 61-year-old female who developed a delayed ischaemic CBD fistula 2 weeks after surgery. All the complications were successfully treated conservatively. No patients developed delayed gastric emptying or ductal stenosis. There was no cholecystitis or pancreatitis. The mean post-operative hospital stay was 11.5 days (range 6–25 days). Histopathology revealed serous cystic adenoma (SCA) in five patients, mucinous cystic neoplasia (MCN) in three patients, intraductal papillary mucinous neoplasia (IPMN) in three patients. There was one patient who had a solid pseudopapillary neoplasia (SPN) (Table 1). All the tumor resection margins were histopathologically negative. All the patients were regularly followed-up, and there was no tumor recurrence.

Discussion

The increasing use of high resolution CT/MR and endoscopic ultrasonography has increased the diagnostic and accuracy rates of cystic tumors of the pancreatic head in recent years. Most tumors are benign but with a risk of potential malignant transformation, or are low-grade malignant tumors [13]. Some of these patients need to be treated by surgery because of symptoms like abdominal pain, distension, and jaundice, or because of the possibility of malignant transformation [14, 15]. DPPHR was initially designed for chronic pancreatitis. Although many surgeons believe that DPPHR results in improvements in intermediate- and long-term outcomes which include the length of hospital stay, quality of life, post-operative rehabilitation, and preservation of exocrine function compared to PD and pylorus-preserving pancreaticoduodenectomy (PPPD) [1, 2]. Although a multi-center, randomized, controlled, double-blind ChroPac trial published in 2017 showed DPPHR to result in no difference in quality of life compared with partial pancreatoduodenectomy for chronic pancreatitis [16], DPPHR has recently been used to treat benign or low-grade malignant tumors in patients who are completely different to those with chronic pancreatitis. These patients are predominantly young females with normal pancreatic functions. A significant proportion of these patients wish to undergo minimally invasive treatment, not only because of small incisions, but also because of organ-preservation. A systematic review showed DPPHR significantly preserved the levels of exocrine and endocrine pancreatic functions, with no significant differences in the rates of pancreatic fistula, delayed gastric emptying and hospital mortality when compared to PD, the standard treatment for tumors of the pancreatic head [17, 18]. DPPHR, by preserving the integrity of the duodenum and biliary system with conservation of the peripancreatic tissues, should better maintain the exocrine and endocrine pancreatic functions in the short- and long-terms. In addition, the operation avoids the complications following a biliary anastomosis.

In the duodenum-preserving partial pancreatic head resection (DPPHRp), which is usually called the classic Beger's procedure, some pancreatic tissues are left to the side of the duodenum and in the distal CBD to preserve the pancreatic duodenal arterial arcade to ensure adequate blood supply to the duodenum, distal CBD and ampulla of Vater. However, partial resection of the pancreatic head requires an additional pancreaticojejunostomy to the remnant pancreatic tissues which increases the risk of pancreatic fistula, and the chance of a positive resection margin in malignant cases [19]. DPPHRt was initially designed to overcome these problems. The limited data available at present suggest DPPHRt to result in low post-operative morbidity and mortality rates and with maintenance of endocrine and exocrine pancreatic functions. Some RCT even showed significant benefits over PD in the long-term [5, 6]. Laparoscopic pancreatic surgery is developing rapidly. Laparoscopic or robotic PD, distal pancreatectomy (DP), and central pancreatectomy, and even a few cases of DPPHRp procedures have recently been reported. These laparoscopic pancreatic procedures have been shown to be technically feasible with reproducible results. Our study on 12 patients who underwent LDPPHRt showed a low risk of complications similar to the open DPPHR procedure [17]. This small study indicated the feasibility and safety of LDPPHRt in selected patients

Table 1 Summary of pre-operative and post-operative data

Case	Gender	Age	Symptom	Pre-operative CT/MR	Lesion diameter (cm)	Operative time (min)	Blood loss (ml)	Anastomosis	Complications	Pathology	Post-operative hospital stay (days)
1	F	34	Abdominal pain	Pancreatic head multilocular cystic lesion	4.5	300	250	Pancreatico-jejunostomy	Pancreatic fistula (B)	SCA	20
2	F	34	None	Pancreatic head cystic lesion	4	310	150	Pancreatico-jejunostomy	Pancreatic fistula (B)	MCN	18
3	F	8	Abdominal pain	Pancreatic head solid-cystic lesion	2.3	220	50	Pancreatico-gastrostomy	None	SPN	6
4	M	47	Abdominal pain	Pancreatic head solid-cystic lesion	4.5	240	200	Pancreatico-jejunostomy	None	IPMN, severe hyperplasia	7
5	F	61	Abdominal pain and jaundice	Pancreatic head multilocular cystic lesion	4.2	210	260	Pancreatico-jejunostomy	Delayed biliary fistula	IPMN	25
6	F	27	Abdominal pain	Pancreatic head multilocular cystic lesion	2	320	80	Pancreatico-jejunostomy	None	SCA	7
7	F	52	Abdominal pain	Pancreatic head solid-cystic lesion	4.8	280	350	Pancreatico-jejunostomy	Biliary fistula	IPMN, severe hyperplasia	17
8	F	35	Abdominal pain	Pancreatic head multilocular cystic lesion	3	260	210	Pancreatico-jejunostomy	None	SCA	7
9	M	56	Abdominal pain	Pancreatic head cystic lesion	3.2	310	300	Pancreatico-jejunostomy	None	MCN	8
10	F	36	None	Pancreatic head multilocular cystic lesion	4.1	300	450	Pancreatico-jejunostomy	None	MCN	10
11	F	30	Abdominal pain	Pancreatic head multilocular cystic lesion	3.9	270	100	Pancreatico-jejunostomy	None	SCA	7
12	F	28	Abdominal pain	Pancreatic head multilocular cystic lesion	3.5	250	180	Pancreatico-jejunostomy	None	SCA	6

with benign or low-grade malignant pancreatic tumors in the pancreatic head. These tumors should not be too close to the duodenum or to the distal CBD. LDPPHRt is not suitable for patients with chronic pancreatitis because inflammation and adhesions make dissection of the pancreatic duodenal arterial arcade difficult. Also, LDPPHRt should be used very carefully in patients with mucinous cystic neoplasms (MCN), because of the possible adhesions and malignant transformation with invasion.

The anterior and posterior pancreatic duodenal arterial arcades are composed of the PSPDA, ASPDA, AIPDA, and PIPDA. They provide blood supply to the descending and horizontal parts of the duodenum. Preservation of these arterial arcades, especially the PSPDA and its branches which supply blood to the distal CBD and the ampulla of Vater, is the key to success in the LDPPHRt procedure (Fig. 2). The complex anatomy of the arcades and their branches make total pancreatic head resection challenging. Autopsy shows the anterior pancreatic duodenal arterial arcade runs typically in the capsule of the pancreas, 0.5–1.5 cm away from the duodenum. Subcapsular dissection of the pancreatic parenchyma preserves the anterior arcade and its branches which go into the duodenum (Fig. 3A). The posterior pancreatic duodenal arterial arcade runs in the mesopancreas, 1.5–2.0 cm away from the duodenum (Fig. 3B). By avoiding the performance of Kocher's maneuver, the mesopancreas remains intact to preserve the posterior arcade, especially the communicating branch between the PSPDA and PIPDA. Laparoscopy provides a good view of these tiny vascular structures for accurate dissection. The total pancreatic head resection is carried out using a medial to lateral approach with the following precautionary steps: (1) DO NOT make a Kocher's maneuvre; (2) Dissect along the GDA to expose the PSPDA to preserve its branches which go into the CBD and ampulla of Vater; (3) The PSPDA passes first along the right edge and then the back of the CBD, so dissecting the

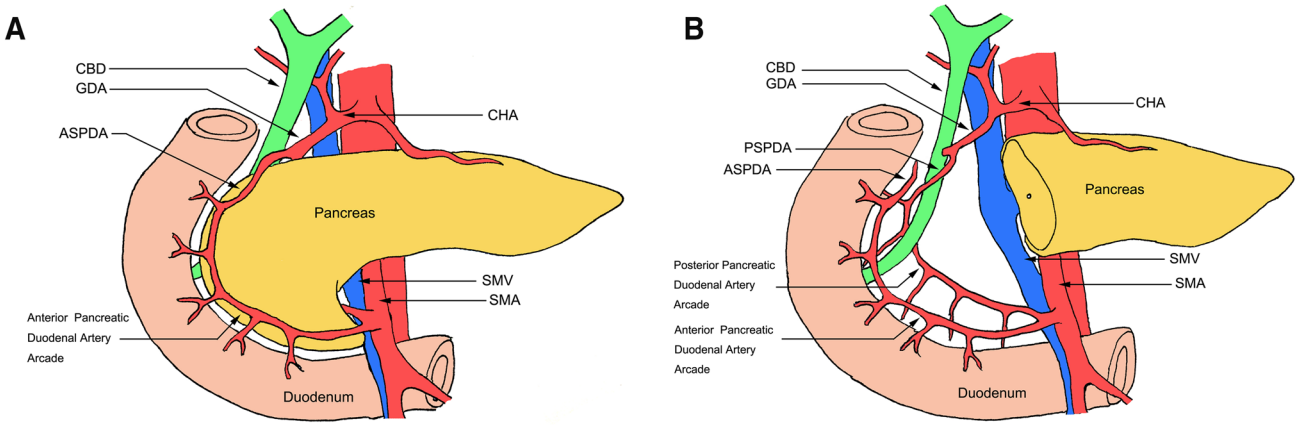

Fig. 2 Schematic representation of total pancreatic head resection. **A** Anatomical structures around the pancreatic head. **B** Completion of total pancreatic head resection while preserving the duodenum, biliary tract and pancreatic duodenal arterial arcades. PSPDA passes first along the right side and then the back of the CBD, so dissecting the pancreas along the left and dorsal sides of CBD is safe

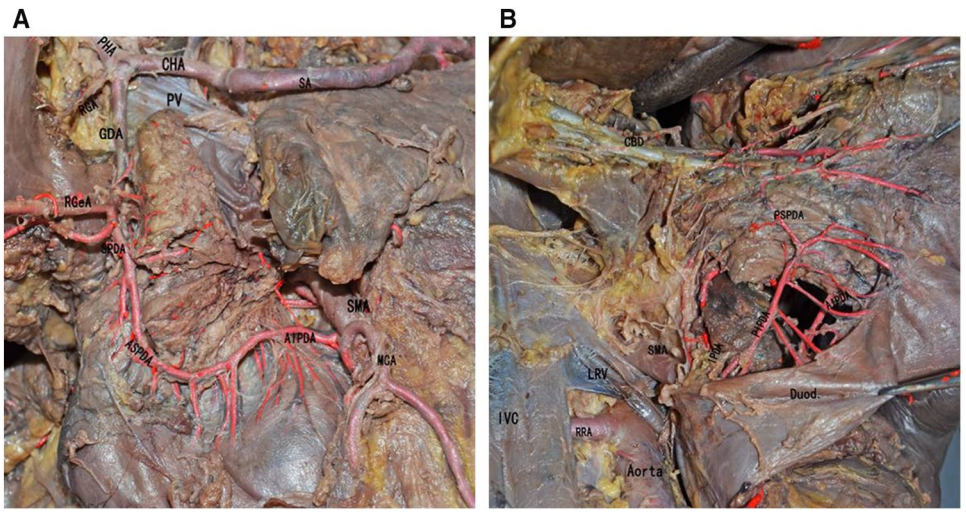

Fig. 3 Autopsy showing the construction of the pancreatic duodenal arterial arcades. **A** The anterior pancreatic duodenal arterial arcade typically runs in the capsule of the pancreas, 0.5–1.5 cm away from the duodenum. **B** The posterior pancreatic duodenal arterial arcade runs in the mesopancreas, 1.5–2.0 cm away from the duodenum

pancreas along the left and dorsal sides of the CBD is safe; (4) Dissecting the uncinate process and then the pancreatic neck to expose the portal vein and SMV, and to build the portal vein-pancreas tunnel; and (5) Do subcapsular dissection at the lower part of the pancreatic head to the right to preserve the inferior pancreatic duodenal arterial arcade.

Conclusion

LDPPHRt is a novel surgical procedure using a minimally invasive approach to achieve good organ-preservation for benign or low-grade malignant tumors of the pancreatic head. Further studies are required to define the long-term oncological outcomes, and the exocrine and endocrine pancreatic functions.

Funding This study is supported by Natural Science Foundation of China (81672420, 81672419, 81572398 and 81702406).

Compliance with ethical standards

Disclosures Drs. Jun Cao, Guo-lin Li, Jin-xing Wei, Wei-Bang Yang, Chang-zhen Shang, Ya-jin Chen, Wan Yee Lau and Jun Min have no conflicts of interest or financial ties to disclose.

References

1. Beger HG, Büchler M, Bittner RR et al (1989) Duodenum-preserving resection of the head of the pancreas in severe chronic pancreatitis. Early and late results. Ann Surg 209(3):273–278
2. Diener MK, Rahbari NN, Fischer L et al (2008) Duodenum-preserving pancreatic head resection versus pancreatoduodenectomy for surgical treatment of chronic pancreatitis: a systematic review and meta-analysis. Ann Surg 247(6):950–961
3. Takada T, Yasuda H, Uchiyama K et al (1993) Duodenum-preserving pancreatoduodenostomy. A new technique for complete excision of the head of the pancreas with preservation of biliary and alimentary integrity. Hepatogastroenterology 40(4):356–359
4. Takada T, Yasuda H, Uchiyama K, Hasegawa H (1995) Completeduodenum-preserving resection of the head of the pancreaswith preservation of the biliary tract. J Hepatobiliary Pancreat Surg 2:32–37
5. Beger HG, Schwarz M, Poch B (2012) Duodenum-preserving total pancreatic head resection for benign cystic neoplastic lesions. J Gastrointest Surg 16(11):2160–2166
6. Beger HG, Siech M, Poch B (2013) Duodenum-preserving total pancreatic headresection: an organ-sparing operation technique for cystic neoplasms andnon-invasive malignant tumors. Chirurg 84:412–420
7. Yuan C-H, Tao M, Jia Y-M et al (2014) Duodenum-preserving resection and Roux-en-Y pancreatic jejunostomy in benign pancreatic head tumors. World J Gastroenterol 20(44):16786–16792
8. Palanivelu C, Senthilnathan P, Sabnis SC et al (2017) Randomized clinical trial of laparoscopic versus open pancreatoduodenectomy for periampullarytumours. Br J Surg 104(11):1443–1450
9. Kutlu Onur C, Lee Jeffrey E, Katz Matthew H et al (2018) Open pancreaticoduodenectomy case volume predicts outcome of laparoscopic approach: a population-based analysis. Ann Surg 267(3):552–560
10. DeRooij T, Lu MZ, Steen MW et al (2016) Minimally invasive versus open pancreatoduodenectomy: systematic review and meta-analysis of comparative cohort and registry studies. Ann Surg 264(2):257–267
11. Peng C-H, Shen B-Y, Deng X-X et al (2012) Early experience for the robotic duodenum-preserving pancreatic head resection. World J Surg 36(5):1136–1141
12. Zhou JY, Zhou YC, Mou YP et al (2016) Laparoscopic duodenum-preserving pancreatic head resection: a case report. Medicine (Baltimore) 95(32):e4442
13. Basar O, Brugge WR (2017) My treatment approach: pancreatic cysts. Mayo Clin Proc 92(10):1519–1531
14. Lawrence SA, Attiyeh MA, Seier K et al (2017) Should patients with cystic lesions of the pancreas undergo long-term radiographic surveillance?: Results of 3024 patients evaluated at a single institution. Ann Surg 266(3):536–544
15. Hackert T, Michalski CW, Büchler MW (2017) Mucinous cystic neoplasms of the pancreas: a surgical disease. JAMA Surg 152(1):26
16. Diener MK, Hüttner FJ, Kieser M et al (2017) Partial pancreatoduodenectomy versus duodenum-preserving pancreatic head resection in chronic pancreatitis: the multicentre, randomised, controlled, double-blind ChroPac trial. Lancet 390(10099):1027–1037
17. Beger HG, Nakao A, Mayer B et al (2015) Duodenum-preserving total and partial pancreatic head resection for benign tumors—systematic review and meta-analysis. Pancreatology 15(2):167–178
18. Beger HG, Mayer B, Rau BM (2016) Parenchyma-sparing, limited pancreatic head resection for benign tumors and low-risk periampullary cancer—a systematic review. J Gastrointest Surg 20(1):206–217
19. Tsuchikawa T, Hirano S, Tanaka E et al (2013) Modified duodenum-preserving pancreas head resection for low-grade malignant lesion in the pancreatic head. Pancreatology 13(2):170–174