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Parenchyma-Sparing, Limited Pancreatic Head Resection for Benign Tumors and Low-Risk Periampullary Cancer—a Systematic Review

Hans G. Beger[1] · **Benjamin Mayer**[2] · **Bettina M. Rau**[3]

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Abstract

Background Parenchyma-sparing local extirpation of benign tumors of the pancreatic head provides the potential benefits of preservation of functional tissue and low postoperative morbidity.

Methods Medline/PubMed, Embase, and Cochrane library databases were surveyed for studies performing limited resection of the pancreatic head and resection of a segment of the duodenum and common bile duct or preservation of the duodenum and common bile duct (CBD). The systematic analysis included 27 cohort studies that reported on limited pancreatic head resections for benign tumors. In a subgroup analysis, 12 of the cohort studies were additionally evaluated to compare the postoperative morbidity after total head resection including duodenal segment resection (DPPHR-S) and total head resection conserving duodenum and CBD (DPPHR-T).

Results Three hundred thirty-nine of a total of 503 patients (67.4 %) underwent total head resections. One hundred forty-seven patients (29.2 %) of them underwent segmental resection of the duodenum and CBD (DPPHR-S) and 192 patients (38.2 %) underwent preservation of duodenum and CBD. One hundred sixty-four patients experienced partial head resection (32.6 %). The final histological diagnosis revealed in 338 of 503 patients (67.2 %) cystic neoplasms, 53 patients (10.3 %) neuroendocrine tumors, and 20 patients (4.0 %) low-risk periampullary carcinomas. Severe postoperative complications occurred in 62 of 490 patients (12.7 %), pancreatic fistula B+C in 40 of 295 patients (13.6 %), resurgery was experienced in 2.7 %, and delayed gastric emptying in 12.3 %. The 90-day mortality was 0.4 %. The subgroup analysis comparing 143 DPPHR-S patients with 95 DPPHR-T patients showed that the respective rates of procedure-related biliary complications were 0.7 % (1 of 143 patients) versus 8.4 % (8 of 95 patients) ($p \leq 0.0032$), and rates of duodenal complications were 0 versus 6.3 % (6 of 95 patients) ($p \leq 0.0037$). DPPHR-S was associated with a higher rate of delay of gastric emptying compared to DPPHR-T (18.9 vs. 2.1 %, $p \leq 0.0001$).

Conclusion Parenchyma-sparing, limited head resection for benign tumors preserves functional pancreatic and duodenal tissue and carries in terms of fistula B+C rate, resurgery, rehospitalization, and 90-day mortality a low risk of postoperative complications. A subgroup analysis exhibited after total pancreatic head resection that preserves the duodenum and CBD an association with a significant increase in procedure-related biliary and duodenal complications compared to total head resection combined with resection of the periampullary segment of the duodenum and resection of the intrapancreatic CBD.

Keywords Benign pancreatic tumors · Tumor extirpation · Pancreatic head · Parenchyma-sparing resection · Duodenum-preserving total head resection · Cystic neoplasms · Neuroendocrine tumors

✉ Hans G. Beger
hans@beger-ulm.de

[1] c/o University of Ulm, Albert-Einstein-Allee 23, Ulm 89081, Germany

[2] Department of Epidemiology and Medical Biometry, University of Ulm, Ulm, Germany

[3] Department of General, Thoracic, Vascular and Transplantation Surgery, University of Rostock, Rostock, Germany

Abbreviations

CBD	Common bile duct
DGE	Delay of gastric emptying
DM	Diabetes mellitus

DPPHR-S	Duodenum-preserving total pancreatic head resection plus segment resection of duodenum and CBD
DPPHR-T	Duodenum-preserving total head resection but conserving duodenum and CBD
DPPHR-P	Duodenum-preserving partial head resection
IPMN	Intraductal papillary mucinous neoplasia
MCN	Mucinous cystic neoplasia
SCA	Serous cystic adenoma
SPN	Solid pseudopapillary neoplasia
PD	Pancreaticoduodenectomy
PNET	Pancreatic neuroendocrine tumor
POPF	Postoperative pancreatic fistula

Introduction

Benign tumors of the pancreas are predominantly cystic neoplasms and neuroendocrine adenomas. Cystic neoplastic tumors, which were first histologically described in 1978 by Compagno and Oertel, in 1982, were further clarified clinicopathologicically as intraductal papillary mucinous neoplasms.[1,2]

Intraductal papillary mucinous neoplasia (IPMN), mucinous cystic neoplasia (MCN), and solid pseudopapillary neoplasms (SPN) are the most challenging benign cystic tumors of the pancreas. They are associated with an increased risk of malignant transformation.[3,4] Pancreatic neuroendocrine tumors (PNETs) are relatively rare, representing approximately 10 % of all benign tumors of the pancreas.[5,6] The most frequent endocrine adenomas are insulinomas of which 5 to 10 % are found to be low to high risk islet cell cancer. All neuroendocrine gastroenteropancreatic tumors are considered to be potentially malignant.[5,6] The increasing use of high-resolution multislice CT and magnetic resonance imaging for diagnosis and screening has resulted not only in high diagnostic accuracy but also in incidental discovery of numbers of benign tumors of the pancreas.[7–11]

For both histopathologic tumor entities, the most important question is set to surgical treatment or surveillance program.

Standard treatment for benign cystic neoplasms and neuroendocrine tumors of the pancreas presently consists of multiorgan resections. A pancreaticoduodenectomy type of resection is the gold standard for lesions of the pancreatic head, while a left-sided pancreatic resection, either spleen preserving or with splenectomy, is used for tumors in the body and tail. However, these surgical procedures are associated with substantial loss of functional pancreatic and extrapancreatic tissues, including the stomach, duodenum, and the biliary tree. Multiorgan pancreatic resections have considerable postoperative morbidity, a substantial risk of mortality, and long-term functional impairments.[12–17]

Tumor enucleation, pancreatic middle segment resection, and duodenum-preserving pancreatic head resections are parenchyma-sparing, limited surgical procedures that are being used for benign pancreatic tumors.[18] They have the potential for low procedure-related postoperative morbidity and for preservation of exocrine and endocrine pancreatic functions. Here, we present results of a systematic review that was performed to evaluate surgery-related postoperative outcomes after total or partial pancreatic head resection for benign cystic neoplasms, neuroendocrine tumors, and low-risk periampullary cancers. In a subgroup analysis, we evaluated the postoperative complications related to total head resection with segment resection of duodenum and common bile duct and after total head resection preserving duodenum and CBD.

Material and Methods

Search Strategy

We conducted an extensive literature search using the electronic databases of PubMed/Medline, Embase, and the Cochrane Library and used the PRISMA statement for reporting systematic reviews and meta-analysis of studies.[19–26] Embase was searched using Emtree terms, and Pubmed/Medline and the Cochrane Library were searched using medical subject headings (MeSH) terms. Additionally, we executed text-word searches for the techniques for pancreatic head resection that were published in the surgical literature. The search items that were used to search for the period from January 1980 to February 2015 were as follows: duodenum-preserving head resection, organ-preserving head resection, segmental resection of the pancreas, inferior pancreatic head resection, pancreas head resection with segmental duodenectomy, limited pancreatic head resection, and uncinatus resection/uncinatectomy.

Initially, there were no restrictions regarding the number of cases, type of publication, and assessment of clinical features. A total of 1579 titles were identified, and in the first step of the selection process, 295 abstracts were read and 93 complete manuscripts were studied. The search results for each of the search items are given in Fig. 1.

Criteria for Inclusion and Exclusion

Of the 93 complete manuscripts, those consisting of reports on 4 or fewer cases undergoing extirpation of benign tumors were excluded. Additionally, manuscripts reporting predominantly results of surgery for inflammatory tumors associated with chronic pancreatitis, those with incomplete core data, and reports that included a large number of cases of limited pancreatic head resection for advanced malignant pancreatic head

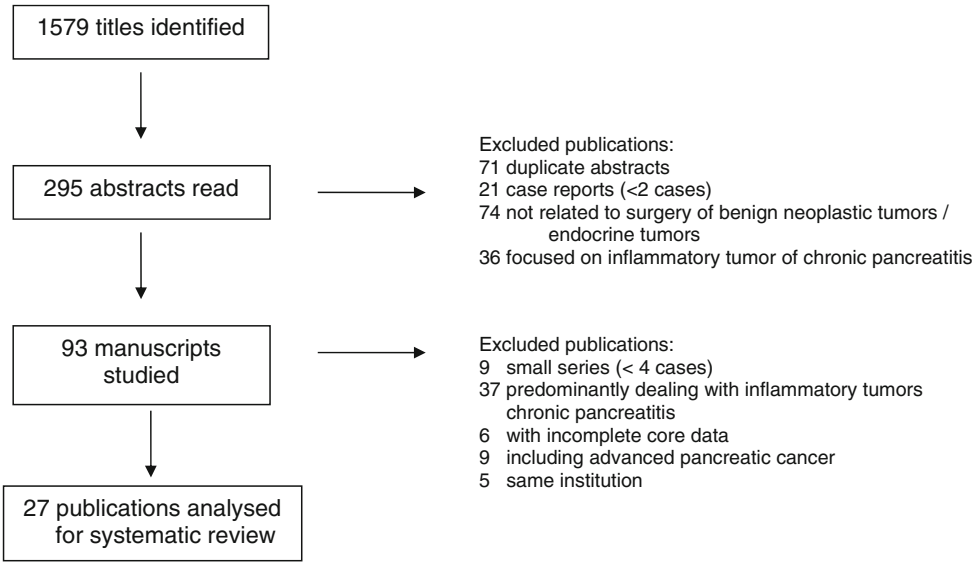

Fig. 1 Data allocation process: PubMed/Medline, Embase, Cochrane Library Search January 1980–February 2015

Search items and results:
Search period: 1/1980 – 2/2015

* Duodenum-preserving head resection	321
Organ preserving pancreatic head resection	69
Segmental resection of the pancreas	162
Inferior pancreatic head resection	71
Duodenum-preserving pancreatic head resection	304
Pancreatic head resection with segmental duodenectomy	16
Limited pancreatic head resection	634
Uncinatus resection/uncinatectomy	2

cancers were excluded. For groups that published several reports on their experience with limited extirpation of pancreatic head tumors, only the most recent publication with the highest number of cases was entered into the final analysis. A total of 27 publications remained for final analysis in the systematic review. Details of the exclusion criteria and the number of excluded reports are presented in Fig. 1.

Data Extraction

We developed a descriptive protocol for identifying all the studies that involved total or partial duodenum-preserving pancreatic head resection (DPPHR) for cystic neoplasms and neuroendocrine tumors of the pancreatic head. Of the 27 final publications remaining for the systematic review, the authors independently performed data extraction 5 separate times from each study, in accordance with prespecified selection criteria. Special attention was paid to the identification of the type of local pancreatic head resection, their postoperative procedure-related complications and the final histopathology of the tumor specimens.

The criteria for early postoperative morbidity were based on internationally accepted definitions for the severity of surgery-related postoperative morbidity. The Clavien-Dindo classification for surgery-related postoperative complications was used to identify severe type of complications.[27] We applied the ISGPF-grading for pancreatic fistula.[28] Since international guidelines on delayed gastric emptying after pancreatic surgery were published in 2009, delayed gastric emptying (DGE) was defined for the earlier reports when there were no uniform definitions.[29] For postoperative DGE, a delay in food intake was considered after the seventh postoperative day or the need for gastric tube drainage/redrainage after the seventh postoperative day.

The core data for statistical evaluation consisted of the following: overall morbidity, severe surgery-related morbidity according to the Clavien-Dindo classification grade ≥3, total number of pancreatic fistula and total number of B- and C-grade fistula, frequency of reoperation, DGE, duration of hospital stay, 90-day mortality, and frequency of rehospitalization. Intraoperative data on the duration of surgical procedure and amount of blood loss, as well as the need for postoperative mechanical ventilation, were infrequently reported and were therefore not evaluated. The criteria for defining overall and severe postoperative morbidity and the new fistula grading

system was used in most of the 27 publications included in the systematic review group.

The analysis is based on data of three groups. The systemic review group comprises data of a total of 503 patients that were included in the 27 cohort studies to evaluate the outcomes after surgery and the histopathological diagnosis. To assess specific complications related to surgical techniques of total pancreatic head resection, a subgroup analysis has been performed comparing data of 143 patients, who underwent limited total pancreatic head resection with segment resection of the periampullary duodenum and the intrapancreatic CBD (DPPHR-S group) with data of a subgroup of 95 patients, who underwent total head resection that spared the periampullary duodenum and intrapancreatic CBD (DPPHR-T group, Tables 1 and 2)

Types of Modifications of DPPHR Reported in the Studies

The location, size, and pathohistologic type of tumor determined whether a total or a partial pancreatic head resection was performed. In detail, a DPPHR-S, which includes total pancreatic head resection, resection of a segment of the periampullary duodenum, and the intrapancreatic CBD, was used preserving the neck of the pancreas. Four anastomoses were performed as shown in Fig. 2: end-to-end anastomosis of the duodenum, end-to-side anastomosis CBD-postpyloric duodenum, end-to-side anastomosis of the pancreatic neck to an excluded jejunal loop or to the stomach and a Roux-en-Y jejunal anastomosis. With the exception of one report, all patients undergoing DPPHR-S underwent an additional cholecystectomy.

To preserve the periampullary duodenum and the intrapancreatic CBD, a total pancreatic head resection (DPPHR-T) was extended to the dorsal and ventral pancreatic head segments and the uncinate process, while preserving the neck of the pancreas (Fig. 3). An excluded jejunal loop or the stomach was used for anastomosis of the left pancreas. Partial pancreatic head resection (DPPHR-P) was performed by extirpating the tumor-bearing tissue from the pancreatic head or resection of the uncinate process. Drainage of pancreatic fluids from the duct of Wirsung into the intestine was maintained by a side-to-side anastomosis with an excluded jejunal loop (Fig. 4).

Subgroup Analysis of Postoperative Complications After Total Pancreatic Head Resection

A total of 12 cohort studies were evaluated to compare the early surgery-related postoperative complications after total pancreatic head resection with or without conservation of the duodenum and CBD. Seven of these studies were prospective and five were retrospective; eight were controlled cohort studies (Tables 1 and 2).[30–33,35–39,58,66] One controlled study directly compared DPPHR-S and DPPHR-T, one compared DPPHR-T and DPPHR-P, while six studies used a classical pancreaticoduodenectomy (PD) and/or a pylorus-preserving PD group as controls. Analysis of the two subgroups was conducted according to recommendations for the preferred reporting of items for systematic review and comparison for meta-analysis.[20,22,25,26] Finally, data on surgical procedure-related postoperative morbidity from a total of 143 patients undergoing DPPHR-S and 95 patients undergoing DPPHR-T were compared (Table 6).

Table 1 Clinical data of the subgroup evaluating surgery-related early postoperative complications in 143 patients after total pancreatic head resection with segmental resection of the periampullary duodenum and the intrapancreatic common bile duct (DPPHR-S)

Author/year	Study period	Country	Age mean	Gender m/f	DPPHR			Pancreatic anastomoses	Type of cohort study	Newcastle-Ottawa scale score points
					S[d]	T	P			
Isaji 2001	1996–1999	Japan	ND	ND	18	0	0	G=6[a] J=12[b]	retrospective	7
Murakami 2004	ND	Japan	63	7/1	8	0	0	G=8	prospective	7
Beger 2008	1982–2006	Germany	44	6/9	9	0	6	J=14 Total pancreatectomy=1	prospective, controlled	8
Lee 2010	1995–2007	Korea	47	7/9	16	14	0	G=16 G=14	prospective, controlled	8
Fuji/Nakao 2011	1991–2007	Japan	51	45/32	77	0	0	G=77	retrospective, controlled	8
Kozlov 2014	ND	Russia	ND	ND	15	0	16	D=1[c] J=21 G=9	prospective, controlled	8

DPPHR-S Duodenum-preserving total pancreatic head resection with periampullary segment of duodenum and CBD, *DPPHR-T* total pancreatic head resection preserving duodenum and CBD, *DPPHR-P* partial pancreatic head resection, *ND* no data available

[a] G: with stomach

[b] J: with jejunal loop

[c] D: with duodenum

[d] S : Patients with duodenum-preserving pancreatic head resection and segment resection of duodenum and CBD

Table 2 Clinical data of the subgroup evaluating surgery-related early postoperative complications of 95 patients after duodenum-preserving total pancreatic head resection and preservation of duodenum and CBD

Author/year	Study period	Country	Age mean	Gender, m/f	DPPHR-			Pancreatic anastomoses	Type of cohort study	Newcastle-Ottawa scale score points
					S	T[a]	P			
Hirano 2004	1989–1998	Japan	59	9/4	0	13	0	G=6 J=7	Retrospective	6
Xiong 2007	2001–2006	China	ND	ND	0	22	0	J=22	Retrospective	6
Horiguchi 2010	2004–2008	Japan	59.5	11/10	0	21	0	J=21	Prospective, controlled	8
Lee 2010	1995–2007	Korea	47	5/9	16	14	0	G=14 G=16	Prospective, controlled	8
Tsuchikawa 2013	1994–2011	Japan	61	13/8	0	13	8	G=19 J=2	Retrospective, controlled	8
Perinel 2014	2008–2012	France	59	5/10	0	12	3	G=7 Tot. pancreatectomy=8	Prospective, controlled	8

DPPHR-S duodenum-preserving total pancreatic head resection with periampullary segment of duodenum and CBD, *DPPHR-T* total pancreatic head resection preserving duodenum and CBD, *DPPHR-P* partial pancreatic head resection, *ND* no data available

[a] T : DPPHR -T total pancreatic head resection but preserving duodenum and CBD

Quality Assessment of the Two Subgroups

To evaluate surgical technique-related early postoperative complications, we analyzed the cohort studies that reported data after tumor extirpation by total head resection applying DPPHR-S and DPPHR-T, respectively, and performed a comparison between these two procedures.

Quality assessment of the subgroup cohort studies used in the comparison of DPPHR-S and DPPHR-T was performed to assess the overall strength and quality of evidence for various parameters (Tables 1 and 2). The Newcastle-Ottawa scale, which allows an objective evaluation of the most basic quality aspects of nonrandomized studies with respect to internationally established criteria, was applied to assess the quality of all the included cohort studies.[34] The Newcastle-Ottawa quality assessment scale includes criteria on selection of the exposed and unexposed cohorts, ascertainment of exposure, comparability of cohorts, outcome assessment, and the length and adequacy of follow-up of the cohort. A study with a score ≥8 is considered to be a high-quality study.

The primary objective of this review was to investigate the impact of total pancreatic head resection with and without segmental resection of the duodenum and CBD and after partial pancreatic head resection on outcomes of patients during the early postoperative period.

Statistical Analysis

Analysis was performed using the Statistical Package of the Social Sciences (SPSS) version 16.0. Descriptive statistics

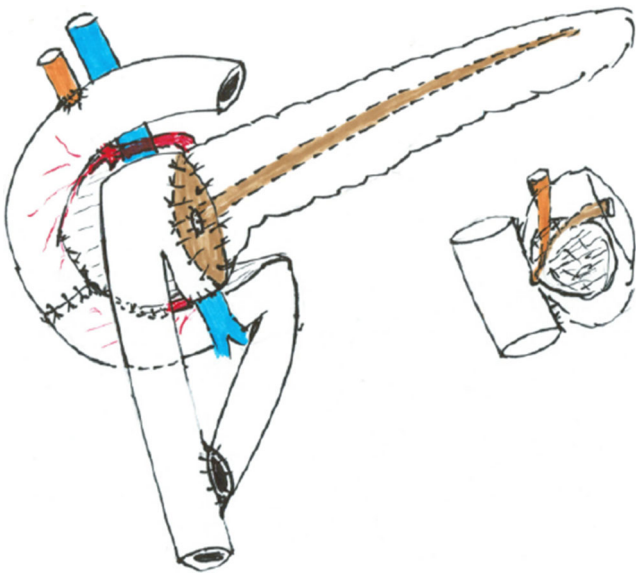

Fig. 2 Total pancreatic head resection with segmental resection of the periampullary duodenum and resection of the segment of the intrapancreatic common bile duct (DPPHR-S)

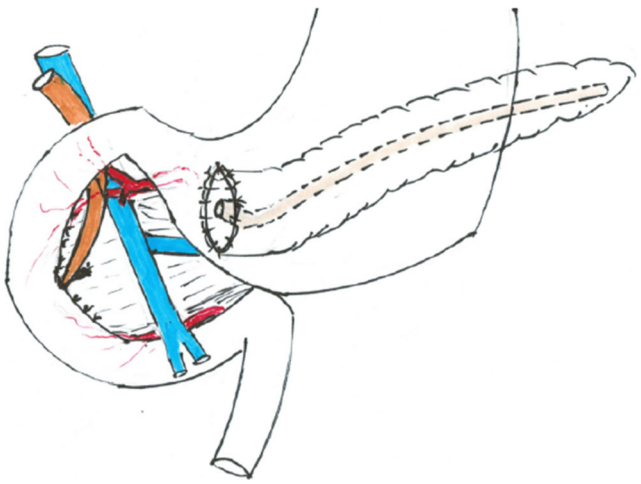

Fig. 3 Total pancreatic head resection and preservation of the duodenum and common bile duct (DPPHR-T). Anastomosis of the pancreas with the stomach

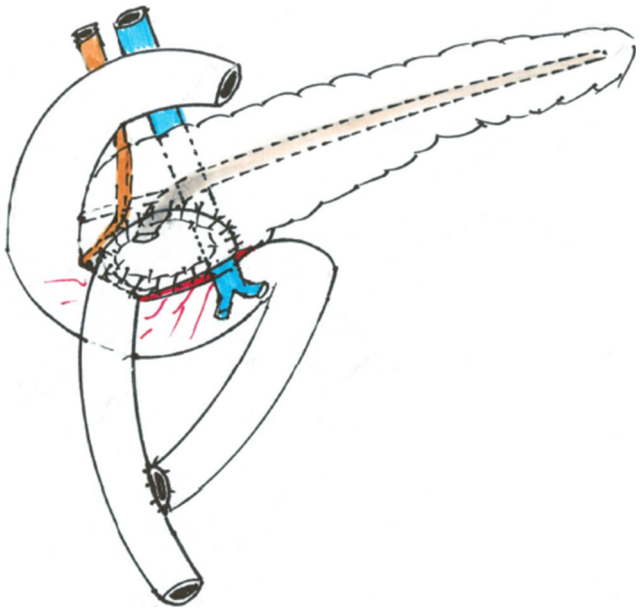

Fig. 4 Partial pancreatic head resection; local tumor extirpation and resection of the uncinate process. Anastomosis of the cavity after resection with an excluded jejunal loop

was performed for all variables. The Student's *t* test was used for pairwise comparison of normally distributed parameters. Continuous variables are presented as median and range for nonparametric data. Variables for early postoperative outcomes were compared using either the Fisher exact test or the Chi-square test. All tests were two-tailed, and results with a *p* value of <0.05 were considered statistically significant.

A meta-analysis could not be performed because only one study compared DPPHR-S and DPPHR-T. However, we did perform an assessment of the comparability of the study and control groups within the included cohort studies, as well as an evaluation of study heterogeneity using the meta-analytic principles of the Newcastle-Ottawa scale.

Results

Systematic Review Group

The final analysis involved 27 studies reporting on 503 patients. The mean patient age was 54.9±5.3 years, and the male to female ratio was 1.0:0.9. Total pancreatic head resection was performed for 67.2 % of the 503 patients, including 147 patients undergoing additionally segmental resection of the duodenum and CBD (DPPHR-S) (Table 3, Fig. 2) and 192 patients undergoing total head resection that preserved the duodenum and CBD (DPPHR-T, Fig. 3). Partial pancreatic head resection that conserved the pancreatic tissue between the CBD and duodenal wall (groove area) and/or spared tissue

Table 3 Application of the limited pancreatic head resection procedures in 503 patients

January 1994–February 2015	DPPHR-S[a]	DPPHR-T[b]	DPPHR-P[c]
503 pts.	147 pts.	192 pts.	164 pts.
100 %	29.2 %	38.2 %	32.6 %

References: [30–33,35–55,58]

[a] DPPHR-S: Duodenum-preserving total pancreatic head resection and resection of the periampullary segment of duodenum and intrapancreatic segment of CBD (Fig. 2)

[b] DPPHR-T: Duodenum-preserving total pancreatic head resection preserving the duodenum and in 169 patients the CBD (Fig. 3). In 23 patients the intrapancreatic CBD was resected

[c] DPPHR-P: Duodenum-preserving partial pancreatic head resection resp. resection of uncinate process (Fig. 4)

of the pancreatic head but removed the uncinate process was performed in 164 patients (32.6 %, Fig. 4).

The most frequent indication for surgical treatment was a cystic neoplasm, which was found in 338 of 503 patients (67.2 %). IPMN (49.7 %) and SCA (7.6 %) were the most frequent cystic neoplasms that required surgical removal (Table 4). The final histopathological examination revealed that 23 of 338 patients (6.8 %) were suffering from a carcinoma in situ of a cystic neoplasm and 8 patients (2.4 %) from a minimal invasive carcinoma of an IPMN and MCN tumor. Among 53 patients (10.5 %) with pancreatic neuroendocrine tumors, 46 were found to be insulinoma on histopathology. Six specimens of the PNETs were finally diagnosed as islet cell cancer; one patient suffered a gastrinoma in the pancreatic head. Twenty patients (4.0 %) experienced surgery for low-malignant periampullary cancer, and of them, ten patients with a cancerous lesion in an adenoma of the papilla of Vater, four patients with a duodenal cancer in an adenoma and six patients had a cancer of the suprapapillary CBD. One patient showed finally a T1 ductal pancreatic cancer. A total of 62 patients (12.3 %) were treated surgically for a malignant lesion. Eighty-eight patients (17.5 %) underwent surgical removal for other histologies, including inflammatory tumors (45 patients), biliopancreatic maljunctions (11 patients, 2 of them finally showed an early cancerous lesion of the CBD), dystrophy of the duodenum (15 patients), gastrointestinal stromal tumor (2 patients), lymphoepithelial cyst (4 patients),duodenal adenoma (2 patients), and 9 patients listed unexplained as "other" lesions.

The size of the resected tumors were reported in 10 studies; measured in 144 patients, the mean size was 3.8 cm (2.4–7.8 cm). The indications to one of the three DPPHR procedures were reported mostly procedure-related but not specified to pathomorphological criteria. Duodenum-preserving total pancreatic head resection was applied in two thirds of the patients suffering IPMN. Patients who showed preoperatively signs of a malignant lesion inside of a large tumor and were

Table 4 Final histological classification of cystic neoplasms, pancreatic neuroendocrine tumors and low-risk periampullary cancers after local pancreatic head resection

	Cystic neoplasms			PNETs[b]		Periampullary[c] low-risk cancer	Other indications[d]
January 1994–February 2015	Cystic neoplasms[a] Total	Carcinoma in-situ/ severe dysplasia	Minimal invasive cancer	Insulinoma	Carcinoma, gastrinoma	Papilla, duodenum, CBD, panc.cancer 1 pts.	
503 pts.	338/503	23/338	8/338	53/503	7/53	21/503	88/503
100 %	67.2 %	6.8 %	2.4 %	10.5 %	13.2 %	4.2 %	17.5 %

PNET pancreatic neuroendocrine tumor, *IPMN* intraductal papillary mucinous neoplasia, *MCN* mucinous cystic neoplasia, *SPN* solid pseudopapillary neoplasia, *SCA* serous cystic adenoma, *CBD* common bile duct

[a] IPMN 250 pts.; MCN 30 pts.; SPN 20 pts.; SCA 38 pts

[b] Insulinoma 52 pts.; gastrinoma 1 pts., islet cell cancer 6 pts

[c] T_1 carcinoma papilla Vateri 10 pts.; CBD 6 pts.; duodenum 4 pts.; DPAC 1 pt.; metastases 3 pts

[d] Other indications: inflammatory tumor, biliopancreatic maljunction, GIST, lymphoma, lymphoepithelial cyst, duodenal adenoma, duodenal dystrophy

found intraoperatively by frozen section harboring a carcinoma in situ underwent, in most cases, a duodenum-preserving total pancreatic head resection with segmental resection of the periampullary duodenum and CBD. The patients suspected to have a periampullary malignant lesion were surgically treated applying a DPPHR-S (Table 4). All patients who suffered a duodenal dystrophy underwent a DPPHR-S procedure. A total pancreatic head resection preserving the duodenum and CBD was used in one third of IPMN and MCN lesions. Most of the patients who were treated for biliopancreatic maljunction underwent total duodenum-preserving pancreatic head resection but additionally resecting the intrapancreatic CBD. Partial pancreatic head resection was used for small cystic neoplasms, serous cystic adenomas, serous pseudopapillary tumors, and for most of the neuroendocrine tumors. Cystic neoplasms and PNETs located in the uncinate process of the pancreatic head was treated by applying resection of the uncinate process.

Data about early postoperative complications were not given for all 503 study patients, except 90-day mortality. Early postoperative overall morbidity after limited pancreatic head resection occurred in 38.2 % of 403 patients (Table 5). Severe surgery-related morbidity was experienced by 12.7 % of 490 patients. Pancreatic fistulae were observed in 92 of 462 patients (19.9 %), 13.6 % of whom had grade B/C fistulae. Of the systematic review group of 503 patients, 5.8 % developed biliary complications and 2.2 % duodenal complications. 12.3 % of patients suffered DGE, and they were predominantly patients who underwent total pancreatic head resection with segmental resection of the duodenum and CBD. The 90-day mortality was in 2 of 503 patients (0.4 %); the frequency of rehospitalization 3.2 %. Long-term follow-up was reported from 325 patients. In the mean follow-up time of 62.9 months, 9 of 312 patients (2.9 %) developed local recurrence (Table 5).

Data About Subgroup Analysis Compared Total Pancreatic Head Resection with Segment Resection of Duodenum and CBD (DPPHR-S) and Total Head Resection Preserving Duodenum and CBD (DPPHR-T)

The mean age of the 143 DPPHR-S patients was 51.3± 8.3 years, and the male to female ratio was 1:0.8 (Table 1). The DPPHR-T patients showed a mean age of 55.2±7.1 years and a male to female ratio of 1:0.95 (Table 2).

The local complications that developed after limited total pancreatic head resection with and without segmental resection of the duodenum and CBD are presented in Table 6. As shown in Table 6, the figures of severe morbidity were similar after DPPHR-S and DPPHR-T.

Pancreatic fistulae developed in both the DPPHR-S and DPPHR-T patients at the same rate (21.9 vs. 22.1 %). Biliary complications occurred more frequently in the patients undergoing DPPHR-T than in the DPPHR-S patients (8.4 vs.

Table 5 Early postoperative morbidity after limited pancreatic head resection for benign tumors and low-risk periampullary cancers

January 1994–February 2015	Morbidity		POPF		Resurgery	Delay of gastric emptying	90-day mortality	Rehospitalization	Recurrence
	Overall	Severe[a]	Total PF	PF B+C					
Total 503 pts.	154/403[b]	62/490[b]	92/462[b]	40/295	10/370[b]	54/439[b]	2/503	9/283[b]	9/312[b]
100 %	38.2 %	12.7 %	19.9 %	13.6 %	2.7 %	12.3 %	0.4 %	3.2 %	2.9 %

[a] Clavien-Dindo ≥3

[b] Denominator: not all publications reported full data about early postoperative course. Percentage represents relation of index occurrence to denominator

0.7 %, $p \leq 0.0032$). Of the eight biliary complications recorded, three were a biliary fistula and five were prepapillary CBD stenosis that caused prestenotic duct dilation and cholestasis. Duodenal complications occurred in none of the DPPHR-S patients and 6.3 % of the DPPHR-T patients ($p \leq 0.0037$). Three of the DPPHR-T patients developed a duodenal leak due to an ischemic lesion of the periampullary duodenum, and three patients developed stenosis of the peripapillary duodenal segment, with prestenotic duodenal dilation causing DGE. The DDHPR-S patients had a significantly higher rate of DGE than the DDHPR-T patients ($p \leq 0.0001$). Pancreatic anastomosis was performed with the stomach in 72.6 % and with a jejunal loop in 26.3 % of the DPPHR-S patients and in 50.8 and 42.6 %, respectively, of the DPPHR-T patients. The frequency of resurgery was 2 of 66 patients and 3 of 95 patients similar for both subgroups, whereas rehospitalization occurred more frequently in the DHPPR-S patients than in the DDPHR-T patients. The 90-day mortality after DPPHR-S was 0 and 2.1 % after DPPHR-T ($p \geq 0.1583$).

Discussion

The results of this systematic review indicate that local pancreatic tumor extirpation using total or partial head resection can be performed with low postoperative surgery-related morbidity and very low hospital mortality. Severe early postoperative morbidity caused by surgical techniques occurred in 12.7 % of 503 patients, pancreatic fistula grades B/C occurred in 13.6 %, and the 90-day mortality was in 0.4 %. The results after limited pancreatic head resection compare favorably with recently published results after classical PD. Multi-institutional reports on major pancreatic resections document a considerably high level of severe postoperative complications and a substantial risk of mortality associated with PD.[12–15] The long-term outcome after classical PD is negatively affected by reduction in the exocrine and endocrine functional capacity of the pancreas.[16,17] A recently published meta-analysis about functional changes before and after total DPPHR and classical PD revealed that the exocrine and endocrine pancreatic functions

Table 6 Early postoperative surgery-related complications after total pancreatic head resection without (DPPHR-S) and with (DPPHR-T) preservation of periampullary duodenum and common bile duct

	DPPHR-S		DPPHR-T		Significance *p* value
Patients	143 pts.		95 pats.		
Severe morbidity[a]	29/143	20.3 %	23/95	24.2 %	0.472[d]
POPF A+B+C[c]	28/143	21.9 %	21/95	22.1 %	0.99 3[d]
Biliary complications	1/143	0.7 %	8/95	8.4 %	0.0032[e]
Duodenal complications	0/143	0 %	6/95	6.3 %	0.0037[e]
DGE[b]	27/143	18.9 %	2/95	2.1 %	0.0001[e]
Resurgery	2/66	3.0 %	3/95	3.2 %	0.99[e]
90-day mortality	0/143	0 %	2/95	2.1 %	0.1583[e]
Rehospitalization	2/51	3.9 %	1/70	1.4 %	0.5723[e]

DPPHR-S duodenum-preserving total pancreatic head resection with periampullary segment of duodenum and CBD, *DPPHR-T* total pancreatic head resection preserving duodenum, *DGE* delayed gastric emptying

[a] Clavien-Dindo≥3

[b] Delay of gastric emptying

[c] Postoperative pancreatic fistula

[d] Chi-square test

[e] Fisher's exact test

following duodenum-preserving total pancreatic head resection were unchanged. It is contrary to PD which showed that pancreatic exocrine and endocrine functions were significantly decreased in short- and long-term follow-ups.[17]

Despite surgery-related diminished pancreatic head tissue, DPPHR procedures maintained endocrine pancreatic functions, as reflected by HbA1c levels, glucose tolerance, and frequency of postoperative new-onset diabetes mellitus (DM).[17] The impairment of endocrine pancreatic functions after PD was recently reported; 18 % of 135 preoperative nondiabetic patients developed postoperative new-onset DM, and 21 of 44 patients (48 %) with preoperative DM experienced an escalation of DM medication requirements.[16]

Of the two types of total pancreatic head resection, the DPPHR-T procedure was associated with a significantly higher level of local complications. The majority of biliary complications after DPPHR-T were stenosis of the prepapillary CBD. Dilation and biliary stenting for both types—biliary stenosis and leakage—of local complications was an effective interventional treatment without the need for reoperation. In total, 6.3 % of the patients, who experienced total pancreatic head resection with conservation of duodenum and CBD, developed duodenal leakage or functional stenosis of the duodenum obviously due to local ischemic lesions of the periampullary duodenum. These lesions were respectively managed by maintaining the external drainage for a longer postoperative period or endoscopic dilation of the narrowed segment of the duodenum in the three patients.

Performing a total pancreatic head resection with preservation of duodenum and CBD resection of pancreatic tissue between the CBD and duodenum, the groove tissue, may cause damage to the posterior-superior pancreaticoduodenal artery. Ligation of the superior-anterior pancreaticoduodenal artery increases the risk of ischemic damage to the prepapillary CBD because branches downstream of this artery supply a small nutrient vessel to the CBD.[55] This papillary branch has been identified in approximately 60 % of patients studied by angiography.[55,56] Preserving the pancreatic head tissue that lies between the intrapancreatic CBD and the duodenal wall reduces the risk of biliary complications after local tumor extirpation as has been shown by the results after DPPHR-P for inflammatory tumors. Preservation of the superior-posterior and the inferior-anterior pancreaticoduodenal artery arcades ensures the blood supply to the peripapillary duodenum.[57] Therefore, careful dissection of the pancreas from the duodenal wall with preservation of the posterior-superior and anterior-inferior pancreaticoduodenal arteries in patients undergoing limited resection of the pancreatic head for benign tumors is recommended. The anterior-posterior pancreaticoduodenal arcades have been identified by angiography in approximately 70 % of patients.[55,56,58] However, there are vascular anomalies of the arterial and venous blood avenues to the pancreatic head and duodenum.[56,58]

The largest part of the pancreas is covered by the head, which is composed of tissues derived from two independent anlagen.[57,59] In performing an extirpation of a tumor while preserving parts of the pancreatic head, resection should take into consideration the embryologically determined segments. The dorsal pancreatic bud gives rise to the dorsal pancreas, which after fusion, contributes to the superior region of the pancreatic head and the body and tail of the pancreas, the duct of Santorini, and the main pancreatic duct of the body and tail. The ventral anlage of the foregut tube forms the inferior region of the pancreatic head, the uncinate process, the duct of Wirsung, and the segment of the intrapancreatic prepapillary CBD. The embryologically different segments of the pancreatic head are connected by a connective tissue septum between the ventral and dorsal regions of the pancreatic head.[57] Local resection of the dorsal-superior or ventral-inferior segments of the pancreatic head has been successfully performed taking into account the embryologically determined segments.[60–63] Tumor extirpation of the uncinate process is a well-established method of partial pancreatic head resection since it consists of local extirpation of the ventral segment of the pancreatic head.[61,63]

In total, 6.8 % of the cystic neoplastic lesions were carcinoma in situ by the final histological assessment. Minimally invasive carcinoma was detected in 2.4 % of cystic neoplastic tumors. Most of the patients with carcinoma in situ and all the patients with minimally invasive carcinoma were identified intraoperatively, and an R0 resection was performed applying total pancreatic head resection with segment resection of duodenum and CBD. Intraoperative frozen-section investigations of both the central part of the cystic neoplasm and the resection margins are recommended for limited resections.[64,65] In 20 of the 503 patients(4.0 %), extirpation of low-risk cancer was performed using total pancreatic head resection with segmental resection of the duodenum and CBD. In patients with low-risk cancer, lymph node dissection of the anterior and posterior nodes of the head and the nodes along the CBD has been performed.[66]

The indications to one of the three duodenum-preserving head resection procedures are not reported for each single patient related to tumor characteristics. The presence of preoperative signs for a malignant lesion, tumor size, and location in the segments of the pancreatic head contributed in 8 of the 27 institutional reports to the selection of the types of pancreatic head resection. In these institutions, the different procedures, total, and partial head resections were at disposal of the surgeons. Nineteen institutions report only results after application of one surgical treatment modality (3 institutions DPPHR-S, 10 institutions DPPHR-T, 6 institutions DPPHR-P). The surgical procedures established in the institution determined the application of the DPPHR procedure rather than the tumor characteristics.

The frequency of tumor recurrence was 2.9 % (Table 5). After an average follow-up interval of 62.6 months, 9 of 312 follow-up patients suffered disease recurrence. Four of nine patients developed recurrence of pancreatic carcinoma, and in

two of these patients, the recurrence was at a distance from the resection line. Resurgery using an oncological PD cured eight of the nine patients. One patient died of distant metastases. None of the patients with low-risk periampullary cancer developed disease recurrence after duodenum-preserving total pancreatic head resection with segment resection of the periampullary duodenum and the intrapancreatic CBD.

This systematic review has several limitations. The data are from 27 institutional cohort studies comprising a total of 503 patients. The studies were conducted over a 20-year period. The definitions of postoperative morbidity by internationally accepted criteria for severity of postoperative complications, types of pancreatic fistula, and degree of DGE have been used since these consensus definitions were first published. All studies included in the analysis, but appeared before the consensus criteria have been published, used well-accepted but slightly different criteria for severity of surgery-related early postoperative severe complications, classification of pancreatic fistula, and degrees of DGE. The management of severe postoperative complications has clearly improved over the last 20 years due to application of less invasive radiological and nonsurgical endoscopic interventions leading to reduced complications and frequency of resurgery.

Based on the criteria for heterogeneity that are applied in meta-analyses, there were no indications of publication bias by the studies we analyzed. The Newcastle-Ottawa scale quality assessment of the 12 subgroup cohort studies that were evaluated to compare surgery-related early postoperative complications after DPPHR-S and DPPHR-T showed that the most basic quality aspects of nonrandomized studies were fulfilled according to internationally established criteria. However, some of the 12 cohort studies consisted of a small number of patients. Additional controlled clinical trials with larger numbers of patients are required to investigate the advantages of total or partial duodenum-preserving pancreatic head resection for benign tumors. Moreover, randomized controlled trials are warranted to verify the advantages of limited pancreatic head resection compared to classical PD for benign tumors of the pancreatic head, regarding early postoperative complications. Data from RCTs are strongly recommended for establishment of limited pancreatic head resection with segmental resection of the duodenum and CBD for low-risk periampullary cancer as a routine surgical procedure.

Summary

Based on 27 publications containing data from 503 patients, this systematic review clearly shows that the use of parenchyma-sparing, limited, total, or partial pancreatic head resection, with and without resection of the peripapillary duodenum and intrapancreatic CBD, is a safe surgical procedure for benign tumors and low-risk periampullary cancers. The benefits of these parenchyma-sparing procedures are maintenance of functional tissue of the pancreas and duodenum, a low rate of severe surgery-related morbidity, low frequency of pancreatic fistula B and C, of reintervention and resurgery, and very low hospital mortality. The use of total pancreatic head resection with and without preservation of the periampullary duodenum and the CBD is associated with procedure-related specific local complications stemming from the duodenum and CBD.

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References

1. Compagno J, Oertel JE Mucinous cystic neoplasms of the pancreas with overt and latent malignancy. Am J Clin Pathology 1978;69: 573–580
2. Ohashi, Murakami Y, Takekashi T et al. Four cases of mucin-producing cancer of the pancreas on specific findings of the papilla of Vater. Prog Dig Endosc 1982;20:348–351
3. Hruban RH, Takaori K, Klimstra DS et al. An illustrated consensus on the classification of pancreatic intraepithelial neoplasia and intraductal papillary mucinous neoplasia. Am J Surg Pathol 2004;28:977–987
4. Levy, P, Jouannad V, O'Toole D, et al. Natural history of intraductal papillary mucinous tumors of the pancreas: actuarial risk of malignancy. Clin. Gastroenterology and Hepatology 2006; 4: 460–468
5. Dralle H, Krohn SL, Karges W et al. Surgery of resectable nonfunctioning neuroendrocrine pancreatic tumors. World J Surgery 2004;28:1248–1260
6. Kunz PL, Reidy-Lagunes D, Anthony LB et al. Consensus guidelines for the management and treatment of neuroendocrine tumours. Pancreas 2013; 42 : 557 – 577
7. Spinelli KS, Fromwiller TE, Daniel RA, Kiely JM, Nakeeb A, Komorowski RA et al. Cystic pancreatic neoplasms: Observe or operate. Ann Surg 2004; 239:651–659
8. Laffan TA, Horton KM, Klein AP, Berlanstein B, Siegelman SS, Kawamoto S et al. Prevalence of unsuspected pancreatic cysts on MDCT. Am J Radiology 2008;191:802–807
9. Lee KS, Sekhar A, Rofsky NM, Pedrosa I. Prevalence of incidental pancreatic cysts in the adult population on MR Imaging. Am J Gastroenterol 2010; 105:2079–2084
10. Girometti R, Intini S, Brondani G, Como G, Londaro F, Brezadola F, et al. Indicidental pancreatic cysts on 3D turbo spin echo magnetic resonance cholangiopancreatography. Abdom Imaging 2011; 36:196–205
11. Brambs HJ, Juchems M. Radiologische Diagnostik zystischer Pankreastumoren. Viszeralmedizin 2011;27:205–213
12. Simons JP, Shah Sa, Ng SC et al. National complications rates after pancreatectomy: beyond mere mortality. J Gastroint Surg 2009;13: 1798–1805
13. Ghaferi AA, Birkmeyer JD, Dimick JG. Variation in hospital mortality associaated with inpatient surgery. N Engl J Med 2009; 361: 1368–1375
14. Castleberry AW, White RR, De la Fuente SG et al. The impact of vascular resection on early postoperative outcomes after pancreaticoduodenectomy. Am Surg Oncol 2012;19:4068–4077

15. Are C, Afuh C, Ravipati L et al. Preoperative nomogram to predict risk of perioperative mortality following pancreatic resections for malignancy. J Gastrointest Surg 2009; 13:2152–2162
16. Burkhart RA, Berger SM, Tholey RM, Lamb KM, Somasundaram A, McIntyre CA et al. Incidence and severity of pancreatogenic diabetes after pancreatic resection. J Gastrointesst Surg 2015; 19: 217–225
17. Beger HG, Nakao A, Mayer B, Poch B. Duodenum-preserving total and partial pancreatic head resection for benign tumors - Systematic review and meta-analysis. Pancreatology 2015;15:167–178
18. Beger HG, Siech M, Poch B, Mayer B, Schoenberg MH. Limited Surgery for Benign Tumors of the pancreas: A Systematic Review. World J Surg. 2015; 39:1557–1566
19. Liberati A, Altman DG, Tetzlaff J et al., The PRISMA statement for reporting systematic reviews and meta-analysis of studies that evaluate health care interventions, explanations and elaborations, Ann Intern Med 2009, 151: 264–269
20. Sutton AJ, Abrams KR, Jones BR et al. Methods for meta-analysis in medical research, John Wiley & Sons, West Sussex 2000
21. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials. 1986;7:177–88.
22. Higgins JPT, Green S, et al. Cochrane Handbook for systematic review of Interventions. Version 5.0.2. The Cochrane Collaboration 2009
23. Kleinbaum DG, Kupper LL, Morgenstern H. Epidemiologic research. Van Nostrand Reinhold Company, New York, 1982
24. Fletcher RH, Fletcher SW, Wagner EH. Clinical epidemiology - the essentials (3rd edition). Williams & Wilkins, Baltimore, 1996
25. Atkins D, Best D, Briss PA, et al. Grading quality of evidence and strength of recommendations. BMJ. 2004;328:1490.
26. Moher D, Liberati A, Tetzlaff J, et al. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med. 2009;6:e1000097.
27. Clavien PA, Barkun J, de Oliveira ML, et al. The Clavien-Dindo classification of surgical complications: five-year experience. Ann Surg. 2009;250:187–96.
28. Bassi C, Dervenis C, Butturini G, et al. Postoperative pancreatic fistula: an international study group (ISGPF) definition. Surgery. 2007;138:8–13.
29. Wente MN, Bassi C, Dervenis C, et al. Delayed gastric emptying (DGE) after pancreatic surgery: a suggested definition by the International Study Group of Pancreatic Surgery (ISGPS). Surgery. 2007;142:761–8.
30. Isaji S, Kawarada Y. Pancreatic head resection with second-portion duodenectomy for benign lesions, low-grade malignancies, and early stage carcinomas involving the pancreatic head region. Am J Surg 2001;181:172–6.
31. Murakami Y, Uemura K, Yokoyama Y et al. Pancreatic head resection with segmental duodenectomy for intraductal papillary mucinous tumors of the pancreas. J Gastrointest Surg 2004;8:713–719
32. Beger HG, Gansauge F, Siech M et al. Duodenum-preserving total pancreatic head resection for cystic neoplastic lesions in the head of the pancreas. J Hepatobil Pancreat Surg 2008;15:149–156
33. Lee SE, Jang AJ, Hwang DW et al. Clinical efficacy of organ-preserving pancreatectomy for benign or low-grade malignant potential lesion. J Korean Med Sci 2010;25:97–103
34. Wells GA, Shea B, O'Connell D et al. The Newcastle-Ottawa scale (NOS) for assessing the quality of non-randomized studies in meta-analyses. http://www.ohsica/programs/clinical epidemiology/htm
35. Kozlov I, Smirnov A, Chzao A. Duodenum-preserving pancreatic head resection and resection of the head of the pancreas combines with segmental duodenectomy. HPB 2014; 16 (Supp. 2): 594–688
36. Hirano S, Kondo S, Ambo Y et al. Outcome of duodenum-preserving resection of the head of the pancreas for intraductal papillary-muninous neoplasm. Dig Surg 2004;21:242–245
37. Xiong JX, Wang CY, Tao J et al. Indication and choice of operation technique for duodenum-preserving resection of pancreatc head: 22 case reports. Zhonghua Wai Ke Za Zhi 2007; 45:24–26
38. Tsuchikawa T, Hirano S, Tanaka E, et al. Modified duodenum-preserving pancreas head resection for low-grade malignant lesion in the pancreatic head. Pancreatology 2013;13:170–174
39. Perinel J, Adham M. Short- and long-term outcome of pancreatectomy with or without biliary tract and duodenum preservation for benign and borderline neoplasms. Dig Surg 2014;31:233–241
40. Harada N. Digestive functions and secretion of gastrointestinal hormones after duodenum –preserving pancreas head resection. Japan J Gastroent Surg 1994;27:781–788
41. Naritomi G, Tanaka M, Matsunage H et al. Pancreatic head resection with and without preservation of the duodenum: Different postoperative gastric motility. Surg 1996:120:831–837
42. Yasuda H, Takada T, Toyota N et al. Limited pancreatectomy: significance of postoperative maintenance of pancreatic exocrine function. J Hepatob Pancreat Surg 2000;7:466–472
43. Yamaguchi K, Yokohata K, Nakano K et al. Which is a less invasive pancreatic head resection: PD, PPPD; or DPPHR?. Digest Dis and Sciences 2001; 46:282–288
44. Takada T, Yasuda H, Amano H, Yoshida M. A duodenum-preserving and bile duct-preserving total pancreatic head resection with associated pancreatic duct-to-duct anastomosis. J Gastrointest Surg 2004;8:220–4.
45. Ito K. Duodenum preservation in pancreatic head resection to maintain pancreatic exocrine function (determined by pancreatic function diagnostant test and cholecystokinin secretion). Hepatobiliary Pancreat Surg 2005;12:123–8.
46. Fernández-Cruz L, Olvera C, López-Boado MA et al. Organ-preserving resection of the pancreaticoduodenal region in the treatment of intraductal papillary mucinous tumors. Cir Esp 2006; 80: 295–300
47. Imaizumi T, Hatori T, Harada N et al. Intraductal papillary mucinous neoplasms of the pancreas; resection and cancer prevention. AJS 2007;194:S95-S99
48. Snajdauf J, Rygi M, Petru O et al. Duodenum-sparing technique of head resection in solid pseudopapillary tumor of the pancreas in children. Pediatr Surg 2009; 19:354–357
49. Busquets J, Fabregat J, Borogia FG et al. Organ-preserving surgery for benign lesions and low-grade malignancies of the pancreatic head: A matched case–control study. Surg Today 2010;40:125–131
50. Pedrazzoli S, Canton SA, Sperti C. Duodenum-preserving versus pylorus-preserving pancreatic head resection for benign and premalignant lesions. J Hepatobiliary Pancreat Sci 2011; 18:94–102
51. Gong DJ, Zhang JM, Mao GH et al. Duodenum-preserving pancreatic head resection vs. pancreatoduodenectomy for benign lesions and low-grade maligancies of the pancreatic head. Hepato-Gastroenterology 2013:60(121) DOI 10.5754
52. Suzuki, R, Hatori T, Szuzki S, et al. The treatment strategy of non-functioning pancreatic neuroendocrine tumor. Pancreatology 2013; 13;S1-S80
53. Liu JZ, Huang UX, Wang HC, Zhen Q. Duodenum-preserving pancreatic head resection versus pancreaticoduodenectomy for bengin pancreatic neoplasms. HBP 2013;15 (Suppl.2),85-244
54. Yuan CH, Tao M, Jia YM et al. Duodenum-preserving resection and Roux-en-Y pancreatic jejunostomy in benign pancreatic head tumors. World J Gastroenterol 2014;20(44):16786:16792
55. Yamaguchi H, Wakiguchi S, Murakami G, Hata F, Hirata K, Shimada K et al. Blood supply to the duodenal papilla and communicating artery between the anterior and posterior pancreaticoduodenal arterial arcades. J Hepato-Biliary Pancreat Surg 2001; (238–244)
56. Petren T. Die Arterien und Venen des Duodenum und des Pankreaskopfes beim Menschen. Z Gesamte Anat 1929; 77:426–432

57. Lewis B. Development of the pancreas and related structures. in: The Pancreas. Ed. Beger HG, Warshaw A, Buechler MW et al. Blackwell Publishers, 2nd Edition 2008; p.42-49
58. Horiguchi A, Miyakawa S, Ishihara S et al. Surgical design and outcome of duodenum-preserving pancreatic head resection of benign or low-grade malignant tumors. J Hepatobil Pancreat Sci 2010;17:792–797
59. Bertelli E, DiGregorio F, Bertelli L, Mosca S. The arterial blood supply of the pancreass: A review. Surg Radiol Anat 1995; 17:97–106
60. Thayer SP, Fernández-del Castillo C, Balconi JH, Warshaw AL. Complete dorsal pancreatectomy with preservation of the ventral pancreas: A new surgical technique. Surgery 2002;131:577–579
61. Suda K, Nobukawa B, Tokare M, Hayashi T. Pancreatic segmentation on an embryological and anatomical basis. J Hepatobiliary Pancreat Sciences 2006;13:146–148
62. Nakagohri T, Kinoshita T, Konishi M et al. Inferior head resection of the pancreas for intraductal papillary mucinous neoplasms. J Heptaobiliary Pancreat Sci 2010;17:798–802
63. Sakamoto Y, Nagai M, Tanaka N et al. Anatomical segmentectomy of the head of the pancreas along the embryological fusion plane: a feasible procedure? Surgery 2000; 128:822–831
64. Fuji T, Kato K, Kodera Y et al. Prognostic impact of pancreatic margin status in the intraductal papillary mucinous neoplasms of the pancreas. Surgery 2010; 148:285–290
65. Frankel TL, La Femina J, Bamboat Z et al. Dysplasia at the surgical margin is associated with recurrence after resection of non-invasive intraductal papillary mucinous neoplasms. HPB 2013;15:814–821
66. Fuji T, Kanda M, Kodera Y et al. Comparison of pancreatic head resection with segmental duodenectomy and pylorus-preserving pancreatoduodenectomy for benign and low-grade malignant neoplasms of the pancreatic head. Pancreas 2011;40:1258–1263